ATP 4-43

Petroleum Supply Operations

July 2014

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Headquarters, Department of the Army

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Petroleum Supply Operations

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Preface

Army Techniques Publication (ATP) 4-43, *Petroleum Supply Operations*, provides techniques on how to accomplish petroleum supply operations while deployed in an operational environment.

The principal audience for ATP 4-43 is personnel of all grades and levels performing in petroleum supply positions. It is also applicable to personnel assigned to operational commands and staffs and provides both of these groups with information necessary to conduct effective petroleum supply operations. Furthermore, ATP 4-43 provides information pertinent to multi-service partners and to units that must interact with multi-service partners.

Commanders and staffs of Army headquarters serving as joint task force or multinational headquarters should also refer to applicable joint or multinational doctrine concerning the range of military operations and joint or multinational forces. Trainers and educators throughout the Army will also use this publication.

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States, international, and, in some cases host-nation laws and regulations. Commanders at all levels ensure that their Soldiers operate in accordance with the law of war and the rules of engagement. (See Field Manual [FM] 27-10.)

ATP 4-43 uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. Terms and definitions for which ATP 4-43 is the proponent publication (the authority) are italicized in text and are marked with an asterisk (*) in the glossary. Terms and definitions for which ATP4-43 is the proponent are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

ATP 4-43 applies to the Active Army, Army National Guard/Army National Guard of the United States, and United States Army Reserve unless otherwise stated.

The proponent of ATP 4-43 is the United States Army Quartermaster School. The preparing agency is the G3 Doctrine Division, Combined Arms Support Commend. Send comments and recommendations on a Department of the Army (DA) Form 2028 (Recommended Changes to Publications and Blank Forms) to Commander, United States Army Combined Arms Support Command and Ft. Lee, ATTN: ATCL-TS (ATP 4-43), 2221 A Avenue, Fort Lee, VA 23801 or submit an electronic DA Form 2028 by e-mail to: usarmy.lee.tradoc.mbx.leee-cascom-doctrine@mail.mil.

Introduction

ATP 4-43, *Petroleum Supply Operations*, provides a single, ready reference for commanders, staff personnel, and Soldiers performing petroleum storage and distribution operations. ATP 4-43 expands the discussion of basic petroleum operations introduced in FM 4-40, *Quartermaster Operations,* and petroleum distribution discussed in ATP 4-93, *Sustainment Brigade*. Combined with these publications, ATP 4-43 provides the reader with a complete understanding of petroleum operations within a geographical area of responsibility to include greater fidelity and detailed techniques for actual operations.

ATP 4-43 contains information and techniques for petroleum operations ranging from basic planning, safety, quality control, systems, and systems maintenance requirements. It also contains discussion on petroleum organizations that could be expected to operate in-theater to provide an understanding of organizations and coordination requirement capabilities.

ATP 4-43 contains five chapters and eight appendices.

Chapter 1 provides a brief discussion of the Army's role in petroleum supply in a theater of operations to give the reader a basic understanding of the mission and responsibilities but without duplicating the information found on sustainment ADPs, ADRPs, and FMs.

Chapter 2 provides information on safety aspects of petroleum supply operations to include grounding, bonding, fire prevention and suppression, and introduces petroleum quality surveillance.

Chapter 3 introduces petroleum supply organizations at brigade and echelons-above-brigade levels to give the reader an understanding of where he fits in the petroleum supply hierarchy. It also gives the reader an understanding of units located at echelons above and below to enhance coordination efforts.

Chapter 4 describes the various petroleum storage and distribution systems and the capabilities of each to give the reader an understanding of the types of equipment that is organic to his organization.

Chapter 5 introduces multiservice units and equipment to provide the reader with a basic understanding of other services with which his organization might need to coordinate for either support or replenishment.

ATP 4-43 does not introduce any new terms, rescind any terms or modify any terms.

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Chapter 1

Development of Petroleum Supply

This chapter discusses the Army petroleum mission and how to plan petroleum distribution in a theater of operations. The information in this chapter can be used by all petroleum organizations to properly plan for petroleum storage and distribution operations.

THE ARMY PETROLEUM MISSION

1-1. JP 4-0, *Joint Logistics*, Appendix B, *Supply Commodity Executive Agents*, delineates Defense Logistics Agency (DLA) and service responsibilities for providing bulk petroleum. (See table 1-1.) DLA, as the executive agent, is responsible for providing bulk fuel from the source to the customer (using unit). However, DLA is not manned or equipped to provide bulk fuel during unified land operations and depends on the other services to support DLA's mission by providing transportation and storage when necessary.

Table 1-1. Joint Publication 4-0

CL III Bulk Petroleum, Oils, and Lubricants Subclass: Bulk Petroleum ***Executive Agent – DLA / DLA- Energy***	**Executive Agent** - Acquire, store, and distribute bulk petroleum from source of supply to acceptance by customer. Establish equipment standards and interoperability requirements. Establish customer relationships with defense agencies and friendly forces where U.S. is designated fuels role support nation.
	Services - Provide force structure to operate tactical storage and distribution systems.
	Army - Manage overland petroleum support.
	Air Force - Provide distribution of bulk petroleum products by air.
	Navy - Provide seaward and over-the-shore bulk petroleum products.
	Marine Corps - Maintain capability to provide bulk petroleum to the USMC.
	Combatant Commands - Integrate executive agent supply chain recommendations.

1-2. JP 4-03, *Joint Bulk Petroleum and Water Doctrine,* describes the Army's role in bulk petroleum supply as, "The Army normally provides management of overland petroleum support, including inland waterways, to U.S. land-based forces of all Department of Defense (DoD) components. To ensure wartime support, the Army shall fund and maintain tactical storage and distribution systems to supplement fixed facilities. The Army shall also provide the necessary force structure to install, operate, and protect tactical petroleum storage and distribution systems, including pipelines. In an immature theater, this also includes providing a system that transports bulk petroleum inland from the high-water mark of the designated ocean beach." Thus, the Army is responsible for receiving, storing, transporting, and distributing fuels to all land-based forces from the high-water mark at sea to the using customer.

1-3. To supplement Army petroleum force structure, storage and distribution systems, contracted support may be used in varying capacities, from facilities and equipment to drivers and laborers. The use of contracted support may generate requirements (contracting officer's representative, fuel, housing, meals, maintenance, security, transportation, etc.) that are not immediately visible to the planner. Therefore, supporting contractors, if used must be a consideration for successful planning.

1-4. Under the United States House of Representatives U.S. Code Title X, subtitle b, part I, chapter 307 – The Department of the Army, includes land combat and service forces and such aviation and water transport as may be organic therein. It shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations on land. It is responsible for the preparation of and forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with integrated joint mobilization plans, for the expansion of the peacetime components of the Army to meet the needs of war.

1-5. DOD 4140.25-M Army shall provide:

- Wartime planning and management of overland petroleum distribution support, including inland waterways to US land base forces of all DOD components. To ensure wartime support, the Army shall fund and maintain tactical storage and distribution systems to supplement fixed facilities 1-2.
- The necessary force structure to operate and install tactical petroleum storage and distribution systems, including pipelines. The Army shall maintain laboratories for certification testing of petroleum and related products used in ground vehicle and equipment system applications, and other than fixed-wing aircraft.

RESPONSIBILITIES

1-6. Organizations and designated responsibilities of each during petroleum operations are described as follows.

DEFENSE LOGISTICS AGENCY ENERGY (DLA-ENERGY)

1-7. DLA-Energy provides the Department of Defense with comprehensive energy support. Key military fuels procured include jet propellants (JP) -5, JP-8, and F-76. DLA-Energy is divided into four commodity business units: alternative fuels, facilities and distribution management, direct delivery fuels, and bulk fuels. Each specializes in a specific product or process.

- The direct delivery fuels commodity business unit acquires and manages ground, aviation, and ship propulsion fuels delivered directly to the customer from commercial vendors and through posts, camps, and stations program.
- The bulk fuels commodity business unit is the principal advisor and assistant to the Director DLA-Energy/Deputy Director of Operations in directing the accomplishment of mission responsibilities to provide worldwide support of authorized activities in the areas of contracting, distribution, transportation, and inventory control of: Bulk fuels, including jet fuels, distillate fuels, residual fuels, automotive gasoline (for overseas locations only), specified bulk lubricating oils, aircraft engine oils, fuel additives (i.e., fuel system icing inhibitor), and crude oil in support of the Department of Energy Strategic Petroleum Reserve Program. The Bulk Fuels commodity business unit also provides quality and product technology support for all of the commodity business units in the DLA-Energy.

ARMY PETROLEUM CENTER

1-8. In accordance with DOD 4140.25-M, the Army Petroleum Center is the Army's designated service control point and acts as the Army's liaison to DLA/DLA-Energy. The Army Petroleum Center ensures that DLA/ DLA-Energy programs benefit the Army and that Defense Working Capital Fund programs meet the needs of the overall Army.

1-9. Headquarters Department of the Army G-4 delegated the Army Petroleum Center as the Army representative to the executive agent for class III (B). In accordance with DOD Directive 5101.8, DLA-Energy serves as class III (B) executive agent.

- Executive agent actions are strategic in nature, involve all the Services, and are designed to improve interoperability and create efficiencies.
- The executive agent initiatives offer the greatest potential of shaping the DOD fuels community to best support long-term Army transformation goals.

1-10. Additional missions of the Army Petroleum Center include but are not limited to:

- Validate class III (B) requirements for Army operating locations worldwide.
- Provide technical assistance and readiness assessments.
- Manage sustainment, restoration and modernization requirements for Army capitalized facilities and provide engineering support for those projects.
- Provide technical expertise for installation and operation of tactical bulk petroleum handling systems and automated fuel management systems.
- Establish overall Army quality surveillance programs and manage tactical and base laboratory certification and correlation programs.

JOINT PETROLEUM OFFICE (JPO)

1-11. Combatant commanders must (or should) ensure that fuel support is provided to assigned missions, and accomplished. The combatant commander establishes a JPO as required and, if needed, a sub-area petroleum office (SAPO) to discharge petroleum responsibilities. The JPO's role is to perform area of responsibility-level petroleum planning across all operations. The JPO's responsibility is to ensure all participants, to include the Services, allies, coalition partners, and supporting commands coordinate their requirements and maximize their available fuel support capability to provide effective theater-wide support. The combatant commander's wartime host-nation support and transportation agencies process and coordinate requests from the Service components for host nation support, infrastructure, and petroleum, oils, and lubricants (POL) transportation assets. The close coordination between the combatant commanders' JPO/SAPO, host nation support organizations, and transportation agencies is critical to ensure the timely execution of theater POL sustainment and management. Key responsibilities of the combatant commander's JPO are listed below.

- The combatant commander has the predominant petroleum responsibility within a theater, and this responsibility is discharged by the JPO. The JPO works in conjunction with Service components, SAPO, and DLA-Energy to plan, coordinate, and oversee all phases of bulk petroleum support for U.S. forces employed or planned for possible employment in the theater.
- The planning conducted at this level plays a critical role in crisis action and deliberate planning. It yields a significant portion of the logistics annex and petroleum appendix of virtually all plans and orders. This level of planning focuses on specifying the concept of bulk petroleum support, delegating responsibility, and identifying required reports. The JPO establishes a SAPO when and where one is needed to support specific requirements. The order establishing a SAPO specifies the mission and additional instructions needed to execute the mission.
- Plans should consider: the mission, fuel requirements, fuel quality surveillance, infrastructure, equipment, support units, interoperability of fuel transfer systems, sustainability and survivability, theater-specific factors, and the threat environment. When demand exceeds availability, the JPO develops an allocation system to support the mission that is approved by the combatant commander.
- A mature theater may have available host nation assets (i.e., fuel sources, terminal facilities, pipelines, railways, and trucks) that should be used to offset U.S. requirements. Because the capabilities of host nations, allies, and coalition partners are theater-unique, the JPO/SAPO is responsible for assessing these capabilities and integrating them into plans and operations.

SUB-AREA PETROLEUM OFFICE (SAPO)

1-12. A SAPO is established by the JPO as a subordinate office to perform petroleum planning in an area of operations or joint operations area. There may be more than one SAPO in the theater and these SAPOs are normally required to:

- Conform to the administrative and technical procedures established by the combatant commander and DOD 4140.25-M, *DOD Management of Bulk Petroleum Products, Natural Gas and Coal, Vol. I-IV*.
- Be under the operational control of the JTF commander. Key duties and responsibilities of the SAPO are to:
    - Serve as the resident petroleum logistic expert.

- Manage development and operation of the organic bulk petroleum infrastructure.
- Based upon JFC guidance, allocate fuel in constrained supply situations.
- Coordinate the quality surveillance program.
- Coordinate additional products and bulk fuel resupply into the theater or JOA through DLA-Energy.
- Coordinate overland fuel movements.
- Review and consolidate fuel requirements.
- Identify and submit requirements to the host nation for petroleum logistic support.
- Serve as a conduit to the JPO for bulk petroleum information.
- Submit the bulk stock status reports, feeder reports, and other documents to the JPO as required.
- Execute theater bulk petroleum policy in the absence of the JPO.
- Coordinate with DLA-Energy Regions/Offices, JPO, organic elements, and others as necessary, to ensure seamless petroleum support from the wholesale supplier to the end user.

1-13. The theater sustainment command (TSC) is the materiel manager for a geographic area of responsibility. A TSC may support one or more expeditionary sustainment commands (ESC) as required.

1-14. The ESC, if employed, manages materiel within an AO/JOA.

1-15. The sustainment brigade provides area and direct support to aviation support battalion /brigade support battalion (BSB) and to forward support companies as required.

- Petroleum Support Battalion/supply company.
- Petroleum Transportation company.

1-16. The aviation support battalion or BSB provides support to its parent brigade.

1-17. The forward support company provides support to its habitual supported battalion.

DEVELOPMENT OF PETROLEUM SUPPLY IN A THEATER OF OPERATIONS

1-18. The following is a brief overview of planning with some additional considerations needed to plan petroleum operations. Planning follows a general process: Determine requirements; determine the best way to meet those requirements with an emphasis on using readily-available assets such as roads, pipelines, etc.; and determine what is necessary to support the petroleum supply system. Providing forces with the right fuel, in the right place, and at the right time is the function of petroleum distributions operations. The following questions will aid in the development of the POL Appendix to the Sustainment Annex of the operation order.

- Should a SAPO for resupplying POL be established?
- What is the concept of operations for petroleum support?
- What host-nation support is available?
- What responsibilities do the service components have for petroleum support? Have components provided estimates of POL requirements?
- Have arrangements been made to contract for host nation support or theater support contractor resources with the supported combatant commander, JPO, or DLA-Energy?
- Have POL storage methods and sites been selected? Have security arrangements for the sites been established?
- Have arrangements been made for transportation of POL within the assigned theater?
- The mission, along with planned size and composition of the forces to be supported, should be guiding parameters for planning efforts. The Army uses factors such as troop strength; numbers and types of aircraft, vehicles and equipment; deployment times; intensity and duration of engagement to determine time-phased petroleum requirements. Plans should include these

requirements, all pre-positioned stocks, and sources for resupply. Accurate fuel requirement forecasting is critical to supporting the combat mission. Petroleum requirement planners must receive the necessary training and resources to accomplish this task.

- The capability of petroleum units in the operational area to provide fuel, storage, distribution, and laboratories must be considered. Size, capability, and maintenance status of offshore unloading facilities, terminals, distribution points, and bases are important to the logistic feasibility of the fuel plan. Addressing this data can help determine the need for and method of employment of tactical petroleum terminals, pipelines, hose-lines, and other fuels handling equipment.
- To ensure that petroleum handling and distribution equipment is available for support of operations (e.g., Inland Petroleum Distribution System [IPDS], Advanced Aviation Forward Area Refueling System equipment onboard maritime prepositioning ships, and equipment onboard Offshore Petroleum Discharge System [OPDS] tankers), fuel deployment packages and operational project stocks should be identified and considered for use. In addition, each Service's operating units for the specific petroleum handling systems should be linked to those systems and identified for movement in the plan.
- Identifying the types and arrival dates of units not tied to specific equipment systems and needed for various support roles is critical to any operational success. Timely arrival of engineer units or Logistics Civilian Augmentation Program (LOGCAP) contractors for construction of petroleum facilities and underwater construction teams for OPDS setup are just some of the diverse types of support units that must be identified.
- Interoperability of fuel transfer systems should be considered and resolved in the planning process for at least the following interfaces:
  - Seaport load and off-load facilities and Joint Logistics Over-the-Shore systems.
  - Airbase fuel storage and dispensing systems to receive fuel from commercial or military sources and issue fuel to Service component and multinational aircraft.
  - Shore distribution systems to tactical fuel systems and equipment (e.g., IPDS, Fuel Unit, Fuel System Supply Point (FSSP) and fuel tanker vehicles).
- Sustainability and survivability should be factored into the plan to ensure petroleum support feasibility. Assumptions made should be critically reviewed. Where appropriate, security requirements beyond general user security must be identified.
- Consideration must be given to theater-specific factors such as available commercial and host nation supply sources and transportation assets. Many of these sources of petroleum supply will have political, technical, and economic factors that limit their availability. These commercial and host nation limiting factors must be taken into account when developing the plan to support the deployment, employment, sustainment, and redeployment of forces. Some factors that commanders and planners must take into account include:
  - Security for contractor personnel, fuel equipment, and stocks.
  - Contractor limitations with regard to support.
  - Contractor required logistic support.
- While theater-specific factors may require protection actions for contractor personnel, petroleum equipment, and stocks; quality assurance actions should also be considered. Ensuring adequate security may include specific and appropriate countermeasures against tampering, adulteration, substitution, contamination, and other actions that could make the fuel unusable or potentially damaging to the end user.

REQUIREMENTS COMPUTATION

1-19. Regardless of the method used to determine petroleum requirements, the result is an estimate based on inputs. For this reason it is important to use the most critical assumptions in determining requirements.

1-20. Petroleum requirement estimates are generated by Soldiers, equipment density, and operational characteristics (defense, offense, terrain differences, etc.). Changes in force structure, equipment density, pace, weather, and other factors will all affect the accuracy of the estimate. The way you determine requirements will be effected by the information you have available.

PLANNING FOR BULK PETROLEUM SUPPLY

1-21. Logistical planning for petroleum support incorporates the calculation of troop strengths, numbers and types of fuel consuming equipment along with tactical objectives into specific fuel requirements and distribution plans.

1-22. Operational planning includes planning for reaching the rated capacity of the distribution system and for maintaining that capacity to meet requirements placed upon it. This planning occurs before and during operations. Revisions may be necessary because of tactical developments, losses in handling capacity and other factors that keep the system from operating as planned.

1-23. Required on-hand quantities are usually stated as a day of supply (DOS). A DOS is considered the amount of product consumed in one day by a given force under specific conditions. The combatant commander will set the required DOS that must be kept on-hand. A DOS at the sustainment brigade and below consists of the supplies actually on hand. At the theater level, ships waiting to off-load may or may not be counted. The number of DOS required is based on varying factors including the amount of time it takes to get resupplied, the concept of support and risk to the supply line. The DOS requirement will drive storage and distribution requirements.

1-24. Each fuel point must maintain a specific amount of DOS on hand in support of the theater objective. This is known as the stockage objective. The stockage objective must be maintained as a reserve against supply disruptions, surge requirements or destruction of supplies. Approval to go below the stockage objective comes from the combatant commander or his designate.

1-25. Planning Elements and considerations include:

- Amount and type of products (requirements) based on force size, composition and mission. The integration of joint and foreign forces may have requirements that you would not normally anticipate. Plan for a "worst case" scenario to ensure that you can support increased operational requirements, to include additional forces on short notice.
- What resources are available in country (host nation) that can be used to meet operational requirements? This would include resources that can be brought in from neighboring countries. Using host nation resources will free US military resources for other duties.
- How and where will products be received? Different types of bulk fuels as well as packaged fuels may be delivered by different means (i.e., ship versus rail) and arrive in theater at separate locations. One product may even have multiple entry points.
- Storage and distribution points should be located near customers and the bulk fuel main supply route. The bulk fuel main supply route should be separate when possible, but may parallel the normal distribution main supply route.
- Size of individual storage areas will be based on the stockage objective, daily operational requirements and the available tankage and systems used to store and distribute fuels.
- Seasonal requirements or impacts on distribution system/equipment. Weather changes may impact the types of fuel required, the amounts of fuel required or it may if may impact the distribution system such as a rainy season that degrades roads.
- Distribution systems or methods (transportation mode) depend on many factors to include the quantities of fuel, the distance to transport it, how secure the lines of communication are, availability of paved road, railroad among others. Know your area and your requirements for fuel.
- Once the preferred distribution method is determined, are the organizations and personnel required to install, construct, operate, and maintain the system available? If not, adjustments will have to be made.

1-26. The combatant command plan is the basis for all subordinate tactical and sustainment support plans for the theater. This plan sets forth broad concepts, establishes objectives, assigns missions, and allocates available resources. The Joint Petroleum Officer is the combatant commander's key staff member on petroleum matters. Furnishes supply and distribution data for inclusion in the command plan.

1-27. The theater Army commander and staff use the combatant command plan as their guide in preparing the theater Army tactical plan and the theater Army sustainment plan. The theater Army G4 first develops sustainment support concept based on the tactical plan. He then prepares the implementing theater Army sustainment support plan. This type of planning provides the guidance and broad policies upon which operational planning is based. Theater Army planning is started before the theater is established. During operations, the job of theater Army planners is to revise basic plans for the conduct of the operation and for developments in the tactical situation.

1-28. The TSC/ESC is responsible for theater petroleum planning and the theater Army petroleum distribution plan. When a TSC/ESC is not available, planning is done by the designated senior sustainment commander in theater. The theater Army distribution plan is prepared and published as an annex to the theater Army logistic support plan.

- The petroleum distribution plan specifies the storage facilities to be used with required capabilities. Shore storage facilities should be large enough to allow tankers to unload in minimum time. The plan should give the size of terminals, tank farms, laboratories, and other facilities and where they should be placed on a time-phased basis to support the tactical plan.
- The distribution plan must specify troop units needed on a time-phased basis to support the tactical plan. Timely arrival of engineer units to construct petroleum facilities and quartermaster and transportation units to distribute petroleum supplies is critical.
- To make sure that petroleum handling and distribution facilities will be available when needed, the TSC/ESC petroleum officer prepares a projected requirement. All long-range materiel requirements, including facilities, materials, and equipment needed to install and operate the petroleum distribution system, are submitted as a theater operational projected requirement. Procedures are prescribed by AR 710-1 and AR 710-3.
- The TSC/ESC petroleum officer coordinates with other key staff members, senior, adjacent, and subordinate and the Army Petroleum Center to insure that the distribution plan is adequate and can be supported. Transportation, engineer, G3, G5, and others may need to assist in the planning and coordination of plan elements. In addition, if additional support is rendered, it will need to be identified and a part of the planning.

1-29. When Army sustainment support either is not available or not desired, U.S. forces may be supplied through agreements with a host nation. The host nation supplies U.S. forces with common items and services. The type and amount of support provided should be specified in signed agreements and included in wartime sustainment plans of all nations concerned. The amount of support -- civil or military -- that a host nation can provide varies based on its national laws, industrial capability, economy, and willingness to give such support. Regardless of the difficulty in obtaining host nation support agreements, they should be aggressively pursued. Host nation resources will most likely support above brigade combat team (BCT) operations and can significantly reduce support requirements.

1-30. Procedures for mutual support among allied nations are contained in directives agreed upon for civil military cooperation. A host nation can be requested to provide civil resources, including facilities, food, services, or labor. National or allied commanders submit requests for civil military cooperation support to the territorial command of the host nation. Where possible, and preferable, national/allied civil military cooperation agreements are made with the host nation in peacetime.

Developing Petroleum Supply Support System

1-31. DLA-Energy procures bulk fuels and coordinates for delivery to major consuming units. The Army has the mission of distributing the fuel within an operational theater to include supporting joint and allied forces. A sustainment brigade will be designated as the receiving agent for fuel and will have the responsibility of distributing it to using units. DLA procures petroleum products and coordinates the delivery to customer units which may be the Army tactical petroleum unit or using unit when contract or host nation support is available.

1-32. Bulk fuels may be procured in the theater if available and the situation permits. The fuel is then transported to the operational area by ocean going tankers or other means. Low use fuels supporting special purpose equipment such as unmanned aircraft systems may arrive in either as a bulk fuel that has to be packaged by Soldiers, or may already be packaged for forward shipment to outlying sites.

1-33. Large-scale combat operations may justify construction of coupled pipelines or hose-lines to move bulk fuel from receipt and storage areas to other storage/distribution points. When used, the pipeline/hoseline system should extend as far forward as possible to reduce requirements for rail and highway transportation that can result to congestion. Pipeline/hoseline systems can be supplemented by other means (rail, vehicle, barge, aircraft, etc.) for surge capacity or special situations which might not otherwise be met.

1-34. Branch lines (Pipeline/hoseline) are used where practical to supply major users such as airbases and tactical airfields from the pipeline. Tank vehicles, rail tank cars, and hose-lines are used to move bulk petroleum products from operational to the tactical level. Using units are authorized organic equipment to receive bulk fuel and to refuel their internal assets such as generators, vehicles and aircraft without resorting to cans and drums.

1-35. The following are basic principles of petroleum distribution:

- The basic petroleum operating concept is to keep storage tanks full at all times. The schedule for movement of fuel through the system is based on ullage and product demand.
- Daily inspections and quality surveillance throughout the theater of petroleum storage and distribution systems is essential to detect leaks, sabotage, damage, pilferage and contamination.
- Pipelines and hose-lines reduce the need to distribute fuel by road or rail and may reduce the number of Soldiers needed to distribute fuel.
- Continuity of pipeline operations is maintained by integrating multiple modes of communication along the pipeline.
- Distribution is made from bulk terminals and storage areas to the consumer by pipeline, hoseline, rail tank car, barge, tank vehicle, and aircraft. Line-haul operations are usually carried out by transportation medium truck companies (petroleum) assigned to petroleum supply battalions or combat sustainment support battalions.
- The use of packaged fuel is limited to the minimum amount needed for continuous support. Bulk reduction is performed as near to the intended consumer as practical and subsequently distributed by land or air transport.
- In areas where lines of communication are not secure, alternative means of supply, such as air, can be used and the days of supply can be increased to overcome the threat risk to the lines of supply. Air Force capabilities for delivering petroleum products are discussed in chapter 5.

OPERATIONAL ENERGY

1-36. Operational energy is the sum of energy and associated systems, information and processes required to train, move, and sustain forces and systems for military operations. Commanders at all levels must consider ways to conserve or reduce the amount of operational energy resources used in military operations. Through conservation of energy resources, commanders can reduce resupply operations, increase vehicle and equipment efficiency, and reduce environmental damage. A continuous process, commanders must plan and oversee operations to reduce consumption, use alternative energy means, and incorporate the latest energy saving technologies. Employing a combination of best practices, technologies, and discipline in managing and executing supply and field services operations will extend operational reach and reduce mission risk.

Chapter 2

General Petroleum

This chapter discusses general petroleum topics to include safety, fire prevention and fighting procedures, grounding and bonding, fuel characteristics, quality surveillance, sampling and testing of fuels.

SECTION I – SAFETY

2-1. Petroleum products can be handled and stored safely if users understand and respect the unique safety hazards that they present. This section gives POL receipt, storage, and issue safety techniques to include safety, storage, precautions, and hazard control measures. Explosions and fires caused by ignition of combustible mixtures of POL vapors and air cause some of the most serious POL related accidents. Thus, controlling POL vapor formation and ignition sources at all times is critical in accordance with Department of the Army Pamphlet (DA Pam) 385-90, *Army Aviation Accident Prevention Program*.

2-2. Safety training is the key to preventing accidents. Safety training must start during the Soldier's initial entry training and it must continue throughout his military service. All fuel handlers should know about petroleum and the safety principles for handling and using petroleum products. In addition, they should know self-care techniques, fire prevention, first aid, and emergency safety procedures.

2-3. An ignition source must be present in order for fires or explosions to occur; a combustible material (i.e., petroleum vapor) and oxygen are also required. Little can be done to control oxygen in a field environment; however, the following work techniques and guidelines will assist in controlling ignition sources, vapors, and increase the safety of personnel and equipment.

2-4. Control sources of ignition for personal safety, environmental considerations, and conservation and protection of fuel supplies. Static electricity, open flames, equipment sparking, and even sunlight can constitute ignition sources.

- Friction and impact between tools and materials can create sparks. Use only authorized tools, equipment, and clothing. Use explosion proof lights and flashlights.
- Do not use open flames, heating stoves, or other devices (i.e., cell phones, electronic devices) which give off heat, sparks, static electricity and other sources of ignition in petroleum storage and work areas.
- Cigarettes and matches/lighters are the single greatest cause of fires. Their use must be prohibited in the vicinity of POL storage.
- Electrical equipment and wires create fire hazards when they produce exposed electrical currents (arcs and sparks) or when they create excessive amounts of heat. Keep tools and equipment in safe and good working condition.
- Spontaneous heating of a combustible material takes place when its characteristics and the right environmental conditions cause a heat-producing chemical reaction. Pay particular attention to safety data sheet for cleaning and storing instructions. Storing rags and waste in proper containers and disposing of them properly can prevent this.
- Strictly enforce NO SMOKING rules and place "NO SMOKING WITHIN 50 FEET" signs where they can be seen before the individual is within 50 feet of the operation.
- For all petroleum operations, always ground and bond petroleum equipment being used (e.g., pump, filter separator, tank truck, storage tanks, etc.) and the equipment receiving fuel. For more information on grounding and bonding see paragraph 2-16.
- Ensure spark arrestors are on all equipment used in and near petroleum storage areas.

2-5. Control and minimize vapors and combustible materials in order to prevent fire in the event that an ignition source overcomes your protections. In the event a fire occurs, minimizing vapors and combustible materials will ensure that the fire presents less danger and risk.

- Control spills with a proactive spill prevention program.
- Immediately clean up and report spills.
- You cannot just pay attention to your own area. In the event of a spill, vapors will travel outside the immediate area to other areas that may contain ignition sources. Ensure that someone warns adjacent activities that flammable vapors may enter their work area.
- Always inspect tank seams, joints, piping, valves, pumps, and other equipment for leaks. Repair leaks at once. Replace defective hoses, gaskets, and faucets.
- Make sure work and storage areas are well ventilated. Beware of unventilated spaces such as the inside of tank vehicles.
- Use drip pans, catch basins, or absorbent materials. Place them where they are accessible in the event of a leak or spill.
- Fill container carefully (whether filling a 5-gallon can, tank vehicle, or storage tank) and avoid overflow.
- Empty fuel pipelines, storage tanks, drums, cans, or containers contain residual vapors and are more dangerous than a filled container.
- Inspect drums and containers before using. Mark them with some sign of approval if they are fit for use.
- Close containers that hold or have held flammable products.
- Carefully open containers that have or may have had flammable products. Heat can cause pressure to build up, which may suddenly release vapors when the container is opened.
- Inform others in the general area when conducting ventilating and vapor-freeing operations to ensure that no sources of ignition are in or brought into the area.
- Overhead filling is not authorized unless approved and signed by the commander or the commander's designated representative. If you cannot avoid overhead filling, put the filling line inside the tank so that the fuel will be disturbed as little as possible. This helps prevent vapors and the buildup of static electricity.
- Ensure notched handles are only on nozzles with automatic shutoffs. Tend all nozzles constantly while they are being used in refueling operations. If you must use notched handles on nozzles that do not have automatic shutoffs, make sure the notches are modified so that the nozzles must be held open by hand.
- Inspect areas for cleanliness often and properly store and dispose of materials as necessary. Relatively small heat sources easily ignite trash, rags, scrap wood, and other such items.
- Use fire resistant wall lockers and cupboards for storage in petroleum supply areas. Never store newspapers or rags in them.
- Discard petroleum waste in accordance with local procedures and in an environmentally-safe manner.
- Label safety cans or other flammable liquid waste containers with a flash point below 100°F (37.8°C) (e.g., gasoline or JP-4) in accordance with 49 Code of Federal Regulations Part 172.

PERSONNEL PROTECTION

2-6. Personal protection is the key to preventing personal injury. It is the individual Soldier's responsibility to take the necessary measures and precautions (i.e., wearing personal protective equipment, using safe working practices and techniques, learning proper first responder procedures, etc.) that keep him and his fellow Soldiers safe. It is the command's responsibility to ensure that all protective clothing required by the safety data sheet is provided to the fuel handler.

- Observe all safety precautions and procedures.
- Observe safety rules when operating, loading, and transferring products.
- Train personnel to give first aid and artificial respiration.

- Inspect equipment, safety devices, and work areas frequently to ensure safety and to correct hazards.
- Keep the work area free of loose tools, lumber, and other objects that may cause accidents.
- Wear fuel-resistant or rubber gloves and protective clothing to keep fuel off the skin.
- Wear shirt sleeves rolled down and buttoned and do not carry loose items on your person.
- Do not wear any wool clothing items or jewelry that may spark against metal surfaces.
- Avoid exposure to fuel vapors for long periods.
- Use only authorized solvents for cleaning. Do not use gasoline and carbon tetrachloride (or other toxic agents) for cleaning.
- Use walkways on tank vehicles, tank firewalls, and berms.
- Do not load, transfer, or move petroleum fuels if an electrical storm is within three miles.

2-7. Despite all other actions taken, fire may still occur and may erupt forcefully. The following techniques and guidelines will assist you to prepare and take appropriate actions in this event.

- Have a fire evacuation and firefighting plan as applicable and ensure your Soldiers are knowledgeable on what they are required to do.
- Inspect all fire extinguishers/suppression units (hand held, trailer mounted, vehicle mounted, and built in) as required.
- Place fire extinguishers and other firefighting equipment within easy reach (e.g., near equipment, refueling points, etc.) but where it will be safe from a fire.
- A small fire may be extinguished using a fire extinguisher.
- The priority is to prevent personal injury and death. Clear a path by spraying at the base of the fire near the feet of Soldiers who are trapped by a fire. Continue making a path until they are clear of the fire.
- In the case of larger fires, the priority is to prevent the spread of the fire to structures, equipment, and fuel storage areas. This may be accomplished by spraying aqueous film forming foam where you do not want the fire to spread. Another method is to stay vigilant for burning debris and extinguish it as it lands near areas that are to be protected.

PROTECTIVE CLOTHING AND PERSONAL EQUIPMENT

2-8. Personnel must wear protective clothing when handling fuels. It is the command's responsibility to ensure that all protective clothing required by the safety data sheet is provided to the fuel handler. Clothing includes field wear, goggles, hearing protection, gloves, and boots.

2-9. Wear shirt sleeves rolled down and buttoned. Do not wear or carry loose items of clothing. Do not wear the wool sweater when refueling as the material produces static electricity. Do not wear jewelry that might spark against metal surfaces. Ensure footwear is not damaged. Exposed nails can cause sparks.

2-10. The Joint Service Lightweight Integrated Suit Technology (JSLIST) chemical protective ensemble and field protective mask restricts movement and activities. Also, they make it difficult to perform even the simplest tasks. Wear MOPP gear only when threat forces have used CBRN weapons or are likely to do so. MOPP gear should be worn during CBRN training exercises.

2-11. Ensure supervisors do a safety risk assessment on whether Soldiers should wear field gear during fueling operations in the field or when in garrison. Field gear attire should be balanced against the facts that a Soldier could be severely injured from falling off tank vehicles or possibly injured due to the tactical situation (sniper fire, riots during contingency operations). Unless directed otherwise by the Commander, Soldiers should wear full field gear in forward areas, since the danger from related injuries is high and explosion and contamination dangers are relatively low. If a Soldier has their weapon, it needs to be properly secured so it does not get in their way or jeopardize safety while conducting refueling operations. The wear of field gear is at the Commander's discretion.

GROUNDING AND BONDING

2-12. Grounding dissipates a static charge to the earth, usually using a metal rod. The earth, particularly soft damp earth, can accept electrical charges. Charges (when minor) dissipate harmlessly when directed into the earth. In the petroleum community, we direct charges into the ground using grounding rods driven into the earth to the level of permanent ground moisture to provide a conductive path into the ground. When equipment is connected to a ground rod through a conductive material (metal cable) it prevents a static charge from collecting on the surfaces of equipment where it could discharge as a spark. The connection to the equipment must be to a clean unpainted, non-oxidized metal surface.

2-13. Under normal field conditions, install grounding rods as instructed in the equipment technical manual.

2-14. Bonding is performed by connecting two electrically conductive objects with an electrically conducting material (e.g., copper wire) to equalize electrical potential (static charges) between them. Bonding does not dissipate static electricity, but equalizes the charge on the two objects so that a non-controlled discharge (spark) does not occur between the two objects. A spark is most likely to occur when a nozzle is close to a vehicle or aircraft that is to be refueled. A fuel handler should bond the refueling vehicle to the vehicle being fueled in three ways:

- Bond the refueling vehicle directly to the vehicle being refueled.
- Connect the ground wire from the refueling nozzle to a grounding point on the vehicle (remember that refueling hose has a wire connection from end to end and leads back to the vehicle).
- Maintain the bond until the refuel operation is complete and the nozzle dust cap and vehicle fuel cap are replaced reducing fuel vapors. All equipment being used in a petroleum handling operation should remain bonded throughout the operation.

STATIC ELECTRICITY

2-15. Static electricity is an energy charge built up in a material through friction with another electrically-dissimilar material. You can create static electricity yourself by rubbing your feet across a carpet and then you can dissipate the charge by touching something metal such as a doorknob or car door. This produces a spark and a shock to you as the charge dissipates.

2-16. In the same way, the flow of petroleum through hoses and pumps as well as into and out of tanks produces static electricity. Also, the flow of steam, air, and other gases through tank, pump, and hose systems produces these charges. Aircraft or vehicles moving through the air or along roads produce static electrical buildup on them. This buildup cannot be predicted or prevented. However, it is not a danger until it builds into a charge that can spark.

2-17. Static electricity is impossible to eliminate; however, it can be controlled and dissipated. Petroleum handlers should always assume that static electricity is present during all phases of an operation, including long-term storage of products. Sparking (and subsequent fire and explosion) from static electricity is a real and ever-present danger during petroleum operations. The two primary ways to control and dissipate static electricity are bonding and grounding.

2-18. The human body conducts electricity. Outer clothing, especially if it is made of wool or synthetic fiber, builds a charge not only by absorbing part of the body charge but also by rubbing against the body or underwear. When the wearer takes the charged clothes off or moves them away from the body, the electrical tension or voltage increases to the danger point. If the clothes are wet with fuel, they may burst into flames when removed due to the dissipation of static electricity. Exposed nails on worn footwear can also cause sparks. This is a serious danger since fuel spills in refueling areas are common and fuel vapors near the ground ignite easily.

2-19. Before opening aircraft or vehicle fuel ports or doing any other operation that would let fuel vapors escape into the air, fuel handlers should bond them to the container by taking hold of it with a bare hand. If it is an aircraft or piece of metal equipment, they should take hold of a bare metal part with both hands for a few seconds. Although this type of bonding will not completely discharge static electricity, it will equalize the charge of the body with the charge on the equipment.

- Do not remove any piece of clothing (source of static electric spark) within 50 feet of a refueling operation or in an area where a flammable vapor-air mixture may exist.
- Do not enter a flammable atmosphere after removing a garment without grounding yourself first.
- Do not carry a garment once removed back into a flammable atmosphere.
- If a Solider gets fuel on his clothes, he should leave the refueling areas as soon as possible or when refueling is completed. Petroleum handlers should wet their clothes with water before taking them off. If there is not enough water at the site to wet the clothes thoroughly, he should ground himself to a piece of grounded equipment by taking hold of it before taking off the clothes. A skin irritation from fuel is not fatal; the fire that may follow a static discharge from clothes can be fatal.

TANK VEHICLE OPERATIONS SAFETY

2-20. The following are considerations for tank vehicle operations and should be followed when the tactical situation permits.

- When possible, conduct petroleum operations on level ground. Always stop the engine, and set the brakes.
- Always chock the vehicle wheels when it is stopped. Chock the tractor and trailer of tractor-trailer combinations.
- Space tank vehicles a minimum of 25 feet during transfer operations and when parked. Be aware that the tank on an empty tank vehicle is at least as dangerous as a full tank, if not more, due to residual vapors.
- During all loading, unloading, and fuel-servicing operations, keep tractors coupled to tank semitrailers.
- Make sure manhole covers stay open during all loading, unloading, and fuel-servicing operations. This prevents tank collapse or rupture if the tank vent fails. When opening the manhole cover, stand upwind of the cover to avoid inhaling petroleum vapors.
- Check the pressure vacuum relief valves frequently in cold weather to be sure they are operating properly.
- Top load vehicles only during an emergency when bottom loading is not possible and it has been authorized by the commander. Top loading greatly increases the production of static electricity and fuel vapors in the vehicle and also increases the chances of a fuel spill. When top-loading, make sure the drop tube or discharge hose is close to the bottom of the tank. Pump fuel at a reduced rate until the end of the tube is covered; then switch to a normal rate. Have someone constantly observe the fuel level in the tank to prevent overfilling.

PETROLEUM FIREFIGHTING

2-21. The following sub sections discuss the classes of fires, types of firefighting equipment, and key planning considerations.

CLASSES OF FIRES

2-22. Fires are distinguished by four categories:

- Class A fires involve combustibles such as wood, brush, grass, and rubbish. Water is the best agent for extinguishing class A fires.
- Class B fires involve flammable liquids such as gasoline and other fuels, solvents, lubricants, paints, and similar substances that leave no embers. A smothering or diluting agent best extinguishes class B fires.
- Class C fires involve live electrical equipment such as motors, switches, and transformers. A smothering agent which is not an electrical conductor best extinguishes class C fires.

- Class D fires involve combustible metals such as titanium, zirconium, sodium, and potassium. A smothering agent best extinguishes class D fires.

FIRE EXTINGUISHERS

2-23. The primary method for fighting petroleum fires at smaller class III supply points is portable, carbon dioxide fire extinguishers. Place one at each pump, receiving and issuing point and packaged product storage area. Place other extinguishers where Soldiers can access them and critical areas of the supply point quickly. Develop a supply point map showing extinguisher locations. Place a map at each checkpoint and at several locations in the area of operation.

2-24. Locate fire extinguishers (or signs indicating the closest one) throughout the supply point. The extinguishers must be in working order. The following are general rules for the use of fire extinguishers:

- Know HOW to operate the fire extinguisher.
- Know WHICH extinguisher to use for each type of fire.
- CHECK each shift to make sure extinguishers are in place.
- INSPECT frequently to see if extinguishers have been damaged.
- RECHARGE or exchange extinguishers immediately after use.
- FOLLOW MANUFACTURER'S INSTRUCTIONS exactly for charging, maintaining, and using the extinguisher.

FIRE EXTINGUISHER TYPES

2-25. The primary fire fighting tool is usually fire extinguishers. The Army uses both portable handheld extinguishers and wheeled units. Portable handheld fire extinguishers are effective only in a fire's earliest stages. Wheeled fire extinguishers offer more flexibility because they have longer hoses and greater capacities.

2-26. The following are different types of fire extinguishers and their uses.

- **Loaded-stream**. The loaded stream extinguisher is charged with an alkali-metal salt solution and other salts. Potassium salts are part of the charge. Loaded stream is well suited to extinguish Class A fires immediately and helps keep them from starting again.
- **Carbon dioxide.** The carbon dioxide extinguisher comes in many sizes. The charge of liquid carbon dioxide under 800 to 900 pounds per square inch (psi) pressure is released by a hand valve at the top of the unit. carbon dioxide dilutes air in Class B fires. It works well on Class C fires because it is not a conductor.
- **Dry chemical.** The dry chemical extinguisher is available in a wide range of sizes. The chief agent is sodium bicarbonate powder with additives that produce water repellency and free flow. The extinguisher puts out the fire by smothering it. It works well on Class B and C fires.
- **Purple-K.** The Purple-K extinguisher is a dry chemical extinguisher using the extinguishing agent potassium bicarbonate , commonly called Purple-K. This fire extinguisher is designed for use on Class B and C fires. Purple-K is highly corrosive. Purple-K extinguishers usually have a 20-pound capacity.
- **Twin Agent Unit.** This is a fire suppression system that is standard with large Class III bulk supply systems. It has the capability of extinguishing 1500 sq. ft. petroleum fire with two agents; potassium bicarbonate powder and aqueous film forming foam.

FIREFIGHTING PLAN

2-27. To fight and extinguish petroleum fires effectively requires a good plan. Every Class III supply point operation should have a fire prevention and firefighting plan. This plan should cover all possible fire problems in detail. It should also cover firefighting resources, to include fire departments and engineer firefighting teams (where available). Soldiers and their supervisors at the Class III supply point have the primary responsibility for controlling and extinguishing fires. However, they should immediately notify their chain of command and outside support agencies, such as the fire department, when a fire breaks out. Ensure your firefighting plan covers these areas.

FIRE INSPECTIONS

2-28. The key to petroleum fire safety is an active prevention program. Where the tactical situation allows for periodic fire inspections, make sure all possible fire prevention precautions are in place and are being followed. Ensure the inspection program covers the entire operation. Here are some key inspection points:

- Make sure fire extinguishers are fully charged, properly placed, and clearly marked. They must also be protected, ready for use, and available in the number and type required.
- Check all equipment, grounds, bonds, and cathodic protection devices. Correct any conditions that may be a source of ignition. If they cannot be corrected immediately, report it.
- Check dikes around storage tanks for serviceability and adequacy. Ensure dike drains are closed except during supervised draining.
- Inspect pumps for leaks and spills. Ensure leaks and spills are cleaned up and reported immediately. Inspect pump houses, if present, for proper housekeeping and proper ventilation.
- Inspect permanent tank farms to see that dry grass and weeds have been cut. Ensure the cuttings are removed from dikes and tank areas.
- Check areas near where open flames for possible sources of flammable vapor release. Ensure NO SMOKING signs are posted in such locations to ensure that there is no smoking within 100 feet of fuel operations.
- Post and enforce rules covering those areas that permit hot work, such as cutting and welding.

PRINCIPLES OF EXTINGUISHING FIRES

2-29. The following subsection covers basic fire fight principles and procedures.

PERSONNEL

2-30. Assign two people to each fire extinguisher in the supply point (three personnel per Twin Agent Unit operation). Make sure all Soldiers in the supply point know and practice procedures for using the fire extinguishers. Also, form a fire fighting team that drills extensively on fire fighting techniques to quickly react to and extinguish larger fires. A five person team is appropriate for the unit level supply point.

EVACUATION ROUTES

2-31. Setup evacuation routes for vehicles and personnel. If a fire breaks out, all vehicles must be quickly moved from the area. Never lock steering wheels on petroleum vehicles. Personnel not involved in fighting the fire must also leave. Evacuation routes should be the most direct route out of the supply point. Show these routes on the maps with the fire extinguisher placement.

FIRE DRILLS

2-32. Use fire drills to train personnel to react quickly to fires. Fire drills should be as realistic as possible. Evacuation routes should be used and fire extinguishers manned. Conduct a fire drill as the tactical situation permits.

FIRE INVESTIGATION

2-33. Investigate all fires to gain knowledge that may help prevent future fires. It is important to know how and why a fire started. Check for an unsafe working condition or an improper act done by a Soldier.

SECTION II – QUALITY SURVEILLANCE

2-34. Quality surveillance is established to maintain the quality of petroleum products from point of origin to point of use. The quality surveillance program encompasses, but is not limited to, bulk fuel in waterborne carriers, tank cars, tank vehicles, pipeline systems, bulk storage, and packaged products. Measures taken include inspecting, sampling, testing, handling, and performing preventive maintenance.

The mission is also to recommend and assist in recovering, upgrading, downgrading, or disposing of products.

Quality Surveillance Organization

2-35. Quality surveillance is defined as the aggregate of measures used to determine and maintain the quality of product receipts, storage of products, and issuing of product to the degree necessary to ensure that such products are suitable for their intended use. This means that certain parameters of the fuel may be outside of their specification limits, but within their use limits.

2-36. In order to meet specifications set at the DOD level, products undergo quality surveillance from the time they are procured until they are used. Therefore, there must be a quality surveillance program throughout the theater of operations.

- The Joint Petroleum Officer, responsible to the theater commander, insures there is a quality surveillance program within the command and monitors and assists in this program. He may be assisted by Joint Petroleum Offices (JPOs) or Subarea Petroleum Offices (SAPOs).
- The theater army command is responsible for setting up and maintaining a quality surveillance program for fuels and lubricants furnished to users by the theater army. The program for bulk and packaged products is carried out by the petroleum group through its petroleum pipeline and terminal operating battalions. A petroleum quality surveillance program is required at all levels of command and will be accomplished by the appropriate petroleum personnel assigned.

2-37. To accomplish this mission, the appropriate petroleum organization:

- Operates and maintains laboratories to test all petroleum products in the command in a reasonable time. Data on testing procedures are contained in the appropriate American Society for Testing and Materials or Federal Test Method Standard . The most current Military Standard (MIL-STD) 3004 and technical manual (TM) 4-43.31 provide guidance and requirements for a quality surveillance system.
- Provides advisory technical assistance to military activities in the theater, particularly in recovering and downgrading products. Laboratory personnel must spend a substantial part of their time in the field on inspections and in connection with quality surveillance problems that arise. When products tested do not meet specification limits, laboratory personnel make recommendations to the Army Petroleum Center for alternate use, reclamation, or disposal. The Army Petroleum Center will make the final disposition decision.
- As required, inspects petroleum products procured in the theater.
- As required, gives technical assistance and performs laboratory analysis for Air Force, Navy, and other commands and agencies.
- Maintains an appropriate fuel sample log to track quality surveillance for storage tanks, facilities, refueling systems, vehicles, and bulk deliveries. The sample log should contain the following: date sampled, name of person taking the sample, sample source, type of sample, date sample results are received, results, and a remarks block.

Personnel Competence

2-38. An effective quality surveillance program requires properly trained personnel. Everyone concerned with handling fuels and lubricants should be suitably trained and able to perform his or her duties. Although the handling of fuels and lubricants presents many hazards, products can be handled safely if product characteristics are understood and precautions are taken. Good housekeeping practices will insure order and cleanliness and will promote safety.

Product Contamination

2-39. Basic sources of product contamination are water, dirt, rust and scale, and intermixing of products. Products may also be contaminated with chemical or biological materials that may not be readily visible. Contaminants change the quality of a product by adding undesirable characteristics that make the product unsuitable for its intended use.

PRODUCT DETERIORATION

2-40. Certain changes occur in stored products and become more marked as the product ages. These changes, which are forms of product deterioration, are mostly the result of natural causes. Although deterioration may be initiated or hastened by storage conditions, it is not usually observable to fuel-handling personnel. The most common forms of product deterioration are weathering, which is the loss of the more volatile components, gum formation, and the loss of oxidation inhibitors, and anti-icing agents. The degree of deterioration can be determined only by periodic laboratory testing.

CAPTURED PETROLEUM PRODUCTS

2-41. Sampling, testing, and other forms of quality surveillance are also performed on captured products. The purpose of such tests or analyses is to identify the products and to make recommendations as to their use, reclamation, or disposal.

2-42. Types of testing are listed as follows.

- Type A.
  - The Type A test is a procurement inspection test. Types B-1, B-2, B-3, and C are performed in quality surveillance testing (see current MIL-STD 3004). In addition, visual checks for appearance, water, and sediment are made on samples at filling points for rail tank cars, tank vehicles, and containers before filling and when changing to fresh fuel tanks and containers. Such checks are also made on delivery-line samples or all-levels samples from tank cars and tank vehicles after loading and before discharge. The types of tests and minimum test requirements are given in the current MIL STD 3004:
  - Suspected contamination of products should be confirmed by laboratory tests.
  - All laboratory tests are performed in accordance with the method prescribed in the appropriate specification. Specifications and deterioration limits are absolute and are not subject to correction for tolerance of test methods. Whether or not a test and its results can be reproduced may determine if the results are acceptable. When the same test is conducted more than once on a given sample, the results are considered suspect if they differ by more than the amount specified in the test method. Minimum test requirements are given in MIL STD 3004C.
  - Each petroleum products laboratory maintains, through publications channels, an up-to-date file of Government fuel and lubricant specifications.
- Sampling.
  - All samples are taken in accordance with standard procedures based on American Society for Testing and Materials standards on petroleum products and lubricants. Many precautions must be taken to ensure that samples are representative. The types of precautions depend on the type of products being sampled; the tank, carrier, or container; and the sampling procedure used. Each sampling procedure is suitable for a specific product under definite storage, transportation, and container conditions. Since a sample is used for determining physical and chemical characteristics of a product, the basic principle of each procedure is to take a sample in such a manner and from such a location in the tank or container that the sample will be truly representative of the product.

2-43. Petroleum products that do not meet specifications are reclaimed for use by downgrading, blending, purifying, or removal of water. Products that cannot be used for their original intended purpose may be furnished for use as a lower grade of the same or similar product or for another use. If this cannot be done, they are reported not suitable for use and are disposed of in accordance with Army Petroleum Center guidance. The Army Petroleum Center is the only Army organization authorized to provide disposition instruction for Army-owned petroleum products that are off-specification.

SECTION III – PETROLEUM ACCOUNTING

2-44. Soldiers storing or transferring Class III products must accurately account for receipt, issue, and stocks on hand for both bulk and packaged products. The biggest challenge in accounting for Class III products (particularly bulk products) is adequately measuring them. This section discusses petroleum accounting records, reports and petroleum measurement techniques. AR 710-2, *Supply Policy Below the National Level;* DA Pam 710-2-1, *Using Unit Supply System (Manual Procedures)*; and DA Pamphlet 710-2-2, *Support Activity Supply System* provide detailed accountability instructions. These include the frequency of conducting an inventory; the percentages of allowable loss of product; determination when a Financial Liability Investigations of Property Loss (FLIPL) is required; amounts of fuel that must be adjusted for temperature; and when accountability is suspended or not required.

BULK PETROLEUM PRODUCT MEASUREMENT

2-45. Bulk petroleum products are measured using the following method:

- Gage the product by measuring the bottom sediment, water, temperature, and height of the product. The height of product in a storage tank can be determined by measuring innage or outage (outage is often referred to as ullage). Innage is the depth of the product from the tank bottom or datum plate to the surface of the product. Outage is the height of space above the liquid from a reference point on the tank to the surface of the product. Gauging is used to determine the amount of product on hand and the amount of water in storage tanks. Also, it is used to detect leaks or unauthorized withdrawals and to determine tank outages for receiving shipments. You must get two identical readings to get an accurate gauge.
- Gauging collapsible fabric tanks will be done using the string and stick method as outlined in Technical Bulletin (TB) 10-5430-253-13. A maximum fill line will be installed on all collapsible fabric fuel tanks to ensure maximum capacity is not exceeded.
- After gauging, calculate the net quantity of the product at 60°F (15°C). This step is needed because petroleum volume varies with temperature. The standard temperature on which to base accountability measurement is 60°F (15°C). AR 710-2 gives gauging and volume correction policies.

MEASURING EQUIPMENT

2-46. Special equipment is needed to measure bulk petroleum. Innage and outage are the two basic ways of measuring bulk petroleum. Innage is the depth of the product from its surface to the tank bottom or datum plate. Outage is the height of space above the liquid from a reference point on the tank to the surface of the product. This equipment is given below:

Tape and Bob

2-47. The two types of tape and bob are innage and outage. They are used to measure petroleum in fixed storage tanks. Both are graduated on one side to 1/8-inch divisions. The tip of the bob is the zero point of the tape and bob. On an outage tape and bob, the zero point is the point of contact between the snap and the eye of the bob.

Petroleum Gage Stick

2-48. A petroleum gage stick is used to determine the innage of a tank vehicle or unpressurized tank car. The stick is graduated in 1/8-inch divisions from the bottom upward. The bottom of the stick usually has a hard metal tip. The gage stick should be long enough to gage the entire height of a tank. When using the stick, make sure to lower it vertically into the tank Make sure it does not rest on a rivet head or other object within the tank. When lowering the stick, be do not splash the product and cause an inaccurate cut.

Tank Vehicle Gage Stick

2-49. Each tank vehicle has its own gage stick which is graduated in 25-gallon divisions. The only difference in use between this stick and the petroleum gage stick is that the product cut is recorded in gallons. Estimate as closely as possible the indicated volume when the cut mark falls between divisions. The 5,000-gallon tank semitrailers have gage sticks marked at the top to show which scale to use for each tank compartment.

Tank Car Gage Stick

2-50. Use the tank car gage stick to determine dome innage and shell outage in unpressurized rail tank cars that have shell outages of 1 foot or less. If the tank car has more than 1 foot of shell outage, use a petroleum gage stick or an innage tape and bob. The 36-inch-long tank car gage stick is made of hardwood or similar material. The stick has two scales, with a common zero mark 12 inches from the lower end, graduated upward and downward in 1/8-inch divisions. A brass angle is used to position the gage stick. The angle is attached at the zero mark on the gage stick.

PORTABLE PETROLEUM SAMPLING AND GAUGING KIT

2-51. The portable petroleum sampling and gauging kit is used at bulk storage facilities when those facilities use other than collapsible fabrics fuel tanks. It is used to gage tanks, take samples and measure temperature of the fuel.

TEMPERATURE MEASUREMENT

2-52. Take product temperature (When required by AR 710-2 or the command) when a tank is gauged to enable the conversion of measured quantity to the net quantity at 60°F (15°C). When gauging large amounts of product, take multiple temperature readings based upon the height of the product in the tank and then average the temperatures for a more accurate representation.

VOLUME CALCULATIONS

2-53. Do volume calculations according to AR 710-2 and this paragraph. Capacity tables showing quantities of either innage or outage gages should be based on certified tank calibration data. The certified calibration charts should be checked when repairs and modifications are made to the tank. The following paragraphs discuss volume calculations for liquid petroleum products:

Total Measured Quantity.

2-54. From the tank strapping chart find the total measured quantity corresponding to the product gage. If using a gage stick calibrated in gallons, determine total measured quantity directly as read from the gauging stick.

- If the tank capacity table is an outage table and an innage gage has been obtained, convert the innage to outage gage. To do this, subtract the innage gage from the reference height.
- To convert outage gage to innage gage, subtract the outage gage from the reference height.

Bottom Sediment and Water

2-55. Find the amount of bottom sediment and water corresponding to the cut on the water finding paste from the gage on the strapping chart or from the water cut on gage stick. Subtract this from the total measured quantity to get the uncorrected net quantity of product.

American Petroleum Institute Gravity

2-56. . Measure the American Petroleum Institute gravity with the appropriate hydrometer. Hydrometers used by the Army give both the American Petroleum Institute gravity reading and the observed temperature reading of the sample. The observed gravity reading must be converted to American Petroleum Institute gravity at 60°F (15°C).

Volume Correction Factor

2-57. . Use the volume correction factor to correct fuel volume observed at temperatures other than 60°F (15°C). Do this after correcting the American Petroleum Institute gravity reading at 60°F (15°C). Do volume corrections according to DA Pamphlet 710-2-1. Use the columns in the appropriate table that correspond to the temperatures of the product in the tank and the American Petroleum Institute gravity recorded on the gage sheet to get the factor. Enter this factor as the multiplier on the gage sheet. Appendix G gives more detailed procedures for computing volume correction factors.

Net Quantity of Product

2-58. To determine the net quantity of product, multiply the total measured quantity by the proper volume correction factor. The total measured quantity must be corrected for bottom sediment and water.

Storage Tank Gage Report

2-59. . Record gauging information on DA Form 3853-1 Innage Gage Sheet (Using Innage Tape and Bob), DA Form 3853-2 Outage Gage Sheet (Using Innage Tape and Bob), or DA Form 3853-3 Outage Gage Sheet (Using Outage Tape and Bob). Tabulate the information on these forms every 24 hours to keep an inventory of bulk petroleum products.

FORMS AND REPORTS

2-60. Forms and reports used to account and track for petroleum products and the activities of various operational areas are identified below. This list is not all inclusive and additional forms may be prescribed by the command. A reference document controlling each form is given.

Daily Status Report

2-61. Soldiers operating a Class III facility submit reports showing quantities of product received, issued, and on hand. They submit this report at the times required by their higher headquarters. The report is in the format required by higher headquarters. Although they usually submit this report once a day, commanders may adjust this frequency to meet operational needs. Daily reconciliations between physical gauges, volume corrected quantity, receipts, issues, and totalizer meter readings for dispensing points should be included in the reports.

DA Form 2765-1 (Request for Issue or Turn-In)

2-62. Customers use DA Form 2765-1 to request packaged and bulk products. They may also use it to turn in excess cans, drums, or supplies. Soldiers making an issue should write the issue quantity on the form, initial, and date it.

DA Form 3643 (Daily Issues of Petroleum Products)

2-63. This form is the basic accountability record for receipts and issues at a supply point. The vehicle operator or convoy commander signs the form to acknowledge product receipt.

DA Form 3644 (Monthly Abstract of Issues of Petroleum Products and Operating Supplies)

2-64. Soldiers doing accountability post summarized information from DA Form 3643 to DA Form 3644 to show total monthly issues and receipts. Soldiers at the supply point or their next higher headquarters may prepare this report. If Soldiers at the supply point prepare the report, they must send it to the responsible centralized stock accounting section for accounting record adjustment.

DA Form 4702-R (Monthly Bulk Petroleum Accounting Summary)

2-65. Units use DA Form 4702-R to report all losses or gains revealed by monthly inventories. They may locally reproduce this form on 8 ½-inches by 11-inch paper. Inventory losses reflected on this form that exceed those allowed by AR 710-2 or that are disapproved by the approving authority are cause for a financial liability investigation of property loss. Gains in excess of the allowable limit must be investigated to determine the cause. A copy of the investigation report must be attached to DA Form 4702-R as a supporting document.

DA Form 2064 (Document Register for Supply Actions)

2-66. Personnel operating Class III storage facilities must establish a stock record card or property record for each type or grade of product. DA Form 2064 is used to post accountable records.

Stock/Property Records

2-67. Keep day-by-day stock/property records on a DA Form 1296 (Stock Accounting Record) to show where and how much of each product is on hand at a storage facility.

DA Form 3853-1

2-68. This form is used to record physical inventories of bulk fuel. The use of this form is given in DA Pamphlets 710-2.

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Chapter 3
Petroleum Units and Equipment

This chapter gives a brief description of the petroleum-specific units that support the Army. All petroleum units are dependent on higher-echelon units for Army health system, supplemental transportation, and maintenance support that go beyond the ability of organic design.

PETROLEUM UNITS

3-1. With the advent of modular, multipurpose units it is important to recognize that mission changes affect capabilities. As an example, a unit capable of operating two 300K FSSP in separate locations may be capable of operating only one 800K FSSP. All petroleum units are dependent on higher-echelon units for administrative services, force health protection, supplemental transportation, and maintenance support that are beyond the ability of unit-level support design.

ECHELONS ABOVE BRIGADE

3-2. Petroleum supply and distribution units, company size, to include truck and pipeline distribution, are normally deployed at the theater level but may be found throughout the theater where demand creates a requirement. These units plan for the storage, distribution and quality surveillance requirements for bulk petroleum products entering the theater in support of operations. These units may have specialized teams and detachments attached to it to meet specific mission requirements. (See figure 3-1on page 3-2.)

3-3. Specialized teams and detachments would include those required to meet JPO staffing requirements, liaison teams to coordinate and provide technical expertise to theater staff, and to provide petroleum laboratory support. It is expected that these teams along with the primary unit will provide petroleum technical assistance and advice throughout the theater wherever it is required to include technical inspections and inventory management when appropriate.

3-4. The fuel managed at this level will be under the operational control of the Army but may be owned by DLA-Energy. As such, DLA-Energy is responsible for determining accounting and quality surveillance procedures.

3-5. The Army will field units capable of storing bulk petroleum fuels in large quantities suitable for resupply of multiple brigades. These units will be capable of operating one or more field storage facilities possibly in multiple locations in support of mission requirements. Each company sized unit will be capable of receiving, storing and issuing bulk petroleum products based on specific organization design and tactical employment.

3-6. Petroleum units capable of operating and maintaining large pipeline/hoseline systems capable of distributing bulk petroleum fuels over extended distances using multiple pump stations. Multiple units may be required to operate the whole pipeline/hoseline distribution system.

3-7. Petroleum units are designed to be attached to combat sustainment support battalions, Petroleum Support battalions, and/or sustainment brigades to provide area petroleum support. These units may be modular and tailored to meet the specific needs of units operating in the area being supported. These units will have headquarters, operations, and operational sections to perform the mission. Additional operations sections can be added for increased capabilities or to add a capability.

3-8. When supporting BCTs and functional brigades, the combat sustainment support battalions may be specifically organized with a multi-capable composite supply company (CSC) and a composite truck company. These companies provide water purification, petroleum storage, and troop transport (IBCT only) to the BCT. When supporting multifunctional or functional support brigades performing Corps missions such as out-of-sector operations, the combat sustainment support battalions (CSSB) will also be specifically organized with the same multi-capable composite supply company and composite truck company to augment the support brigade logistics capability. Other CSSBs are organized with functional logistics units based on mission requirements.

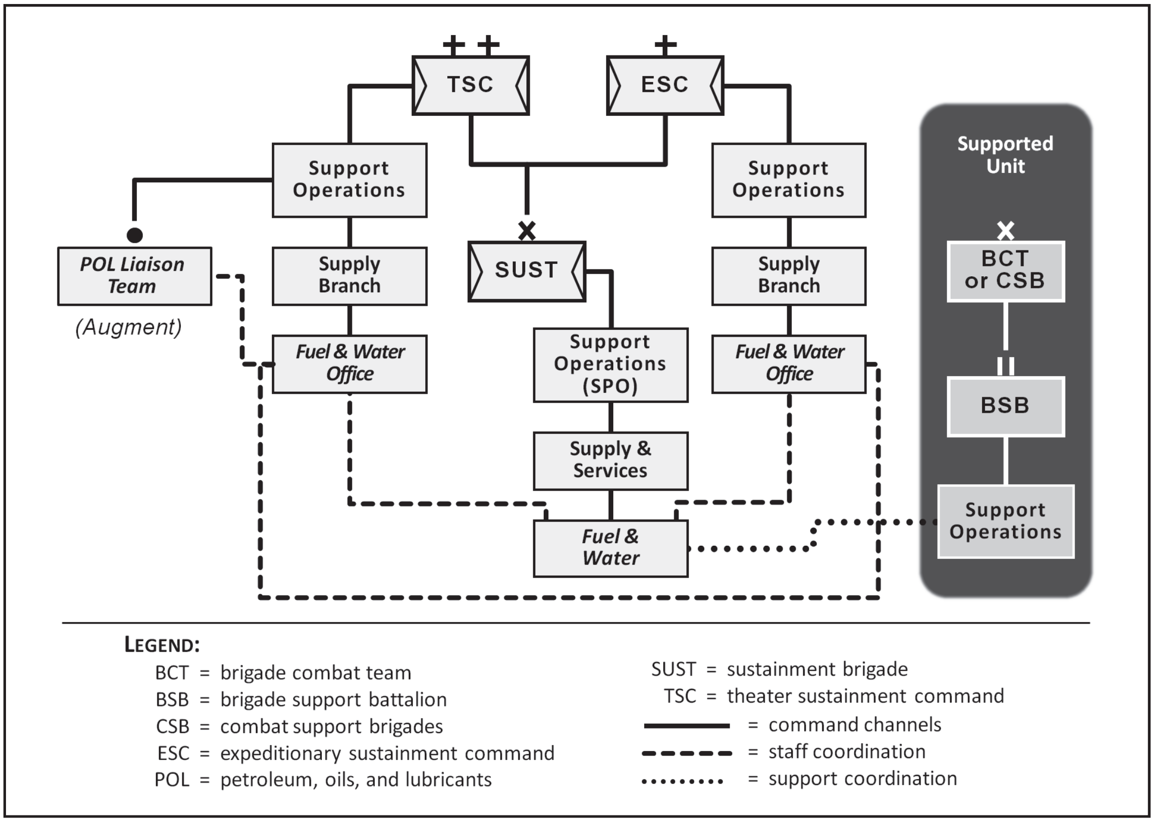

Figure 3-1. Petroleum management

PETROLEUM SUPPORT BATTALION

3-9. This battalion consists of a functional petroleum battalion headquarters in the active component to provide mission command of POL forces, petroleum quality analysis system – enhanced, and provide engineer construction oversight during the early phase of ops. This unit provides an early entry operational and organizational headquarters capability that can mission command POL units, conduct quality analysis and surveillance of POL arriving in theater, and oversee the construction of the inland petroleum distribution system and fuel storage sites. Units tasked organized under this unit will based off mission requirements. It supports theater bulk petroleum storage (meeting DOS requirements) and distribution in accordance with the Bulk Petroleum Distribution Plan. It distributes bulk fuel to sustainment brigades and brigade combat teams (BCTs) as required.

3-10. The headquarters and headquarters detachment, Quartermaster petroleum support battalion provides mission command, administrative, technical, and operational supervision over subordinate petroleum support companies and transportation medium truck companies (Petroleum). Normally assigned to the special troops battalion of the sustainment brigade or TSC, the headquarters and headquarters detachment is dependent on a subordinate petroleum support company for field feeding and maintenance.

3-11. The headquarters and headquarters detachment consists of the following:

- Battalion command section provides necessary command, control, and supervision over petroleum support companies of the battalion and its assigned and attached transportation units.

- Current Operations-Intelligence/S2 section provides supervision for the security and operations of the battalion's military petroleum supply and distribution system.
- Current Operations-Ops/S3 section provides supervision over those activities not classified as sustainment functions but charged to the battalion as tactical missions. The S3 advises and assists the battalion commander in planning, coordinating, and supervising battalion communications, tactical operations, unit training, security, and intelligence functions.
- Sustainment 1 (S1/S2/S4/S6/Unit ministry team) provides personnel management and administrative support throughout the battalion; technical assistance on supply and maintenance to the subordinate units in the battalion; provides 24-hour communication and message service within the battalion headquarters; and advises the commander on ethics, morale and morale development, and religious matters.
- Sustainment 2 (Support Operations) provides a central dispatching element and coordinates bulk petroleum movement by means other than pipeline.
- The Petroleum lab branch conducts analysis of petroleum products received and stored in operating units and provides area petroleum lab support as directed. Equipped with the Petroleum Quality Analysis System – Enhanced, the branch can be employed throughout the operational area to support petroleum operations when total testing (types A & B1) is not required.
- The detachment headquarters provides the necessary command and supervision to include administration, organizational supply, security, and training activities.

3-12. In a theater, there may be multiple petroleum support battalions with two or more petroleum support companies, petroleum pipeline and terminal operating company, and/or transportation medium truck companies (petroleum). This unit plans for the storage, distribution, and quality surveillance of bulk petroleum products required by BCTs and echelons above BCTs, and ensures that a prescribed portion of the corps/theater petroleum reserve is maintained by attached petroleum supply units.

Quartermaster Petroleum Pipeline and Terminal Operating Company

3-13. Petroleum pipeline and terminal operating companies operates petroleum pipeline and terminal facilities for receipt, storage, issue, and distribution of bulk petroleum products in support of an independent corps or theater army area of operations. (See figure 3-2 on page 3-4.)

3-14. While it is normally assigned to a petroleum support battalion, the petroleum pipeline company may also be assigned to a combat sustainment support battalion. This company is dependent on military police support for pipeline security; petroleum laboratory support from the petroleum support battalion; and engineer construction support for pipeline construction, terminal earth work, and road work.

3-15. This unit operates bulk petroleum distribution facilities in support of the theater or sustainment brigades. One company operates up to 75 miles of pipeline distributing up to 720,000 gallons per day and two commercial type tank farms (up to 250,000 barrels each) or one tactical petroleum terminal (TPT) of up to 3.7 million gallons. When necessary, it will operate facilities for shipment of bulk petroleum by coastal tanker, barge, rail, and tank trucks. It also has a FSSP and assault hoseline.

3-16. This unit is responsible for providing technical support for engineer companies assigned to construct the pipeline. Civilian augmentation may be provided for additional technical support on constructing, operating, maintaining, and recovering the pipeline and related equipment.

3-17. The petroleum pipeline terminal operating company consists of the following sections:

- The company headquarters provides mission command, administration, and sustainment support required to conduct unit operations.
- The petroleum products control section receives detailed operating instructions from the system's dispatcher/scheduler or higher headquarters and directs the company elements executing the instructions; performs supply control and accounting functions for bulk petroleum products received, stored, and issued by the company; monitors bulk petroleum requests from operating platoons; and consolidates and forwards appropriate reports to higher headquarters.

- The maintenance section provides unit maintenance on the organic wheeled vehicles, materials handling equipment, compressors, and power generating equipment.
- The terminal operating platoon headquarters supervises the receipt, storage, issue, and distribution of bulk fuels; provides platoon administration, internal safety, and security; and inspects and performs quality surveillance on bulk fuels it handles.
- The tank farm sections provide personnel to operate two fixed bulk petroleum terminals or one TPT. The hoseline allows portable dispensing beyond the reach of the pipeline or as a branch line. Components of the TPT may also be configured to establish a class III supply point for receipt, storage, and issue of three types of fuels from tank trucks or other means of supply. Tank farm and/or storage and issue section personnel may be tasked to operate a beach termination unit for ship-to-shore receipt of fuel from offshore tankers.
- The storage and issue section operates the FSSP, two 5,000 gallon tankers, four tank and pump units, and when required performs limited bulk reduction of petroleum fuels.
- The pipeline operating platoon headquarters supervises and directs operation of approximately 75 miles of multiproduct pipeline and up to five pump stations.
- The service support section provides field and sustainment maintenance on pipeline pump stations and related equipment peculiar to the pipeline system and the TPTs throughout the unit's area of responsibility. Maintenance functions include ordering equipment parts, repairing and replacing valves, blinds, pressure gauges, meters, line strainers, pump units, welded pipelines, coupled lines, hose-lines, and other related pipeline equipment.
- The pipeline sections operate up to five pump stations and patrol the pipeline for leaks, sabotage, and other problems.

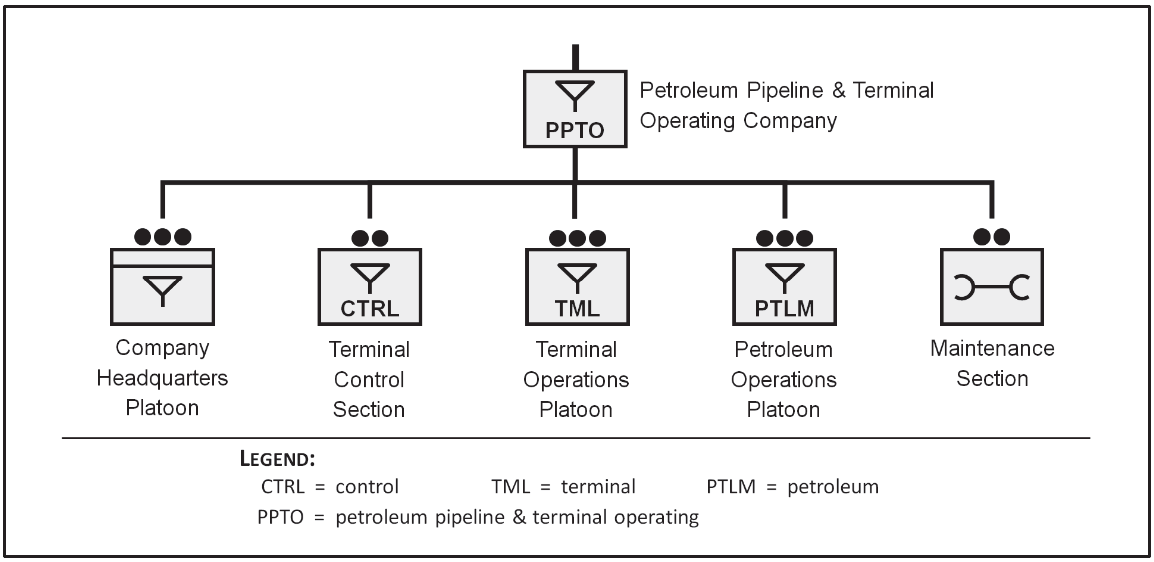

Figure 3-2. Petroleum pipeline & terminal operating company

QUARTERMASTER PETROLEUM SUPPORT COMPANY (MODULAR) (50K OR 210K TANK).

3-18. These are modular petroleum support companies that, when assigned their full complement of subordinate units: (See figure 3-3.)

- Operate three receipt, storage, and issue facilities, with each capable of storing up to 600,000 gallons (50K Tanks) or 1,680,000 gallons (210K Tanks), receive and issue up to 400,000 gallons (50K Tanks) or 645,000 gallons (210K Tank) per day.
- Operate a fuel storage facility connecting into pipeline systems with the use of an emergency take-off point kit.
- Operate bulk fuel railheads and/or fixed class III installations as required.

- Operate up to three area supply support points in direct support of non-brigade units with combined receipt, storage, and issue capability of 360,000 gallons and a distribution capability of 146,250 gallons of bulk petroleum daily, based on 75 percent availability of fuel dispensing vehicles making two trips per day.
- The petroleum support company receives, stores, and issues bulk fuels in support of BCTs and echelons above BCTs. Normally assigned to a petroleum support battalion, the company is employed throughout the echelon above brigade area to provide wholesale and retail POL support. Elements of the company may operate in the brigade support area and can be attached to any of the companies of the combat sustainment support battalion (CSSB) to provide a tailored capability. Normally there is one per petroleum support battalion, but there may be more, based on stated requirements.

3-19. The company headquarters provides mission command, administrative, sustainment support to the petroleum support company and attached elements. This unit is normally assigned to a petroleum support company (50K Bags or 210K Tanks) and employed in the CSSB or theater support area to provide mission command for two to four platoons. Normally, there is one headquarters element per two to four Platoons. This unit provides mission command, administrative, sustainment for all assigned and attached elements.

3-20. The petroleum support company headquarters has the following elements:

- Company headquarters provides mission command, administrative, and sustainment support for assigned and attached units.
- Field feeding support team provides field feeding support.

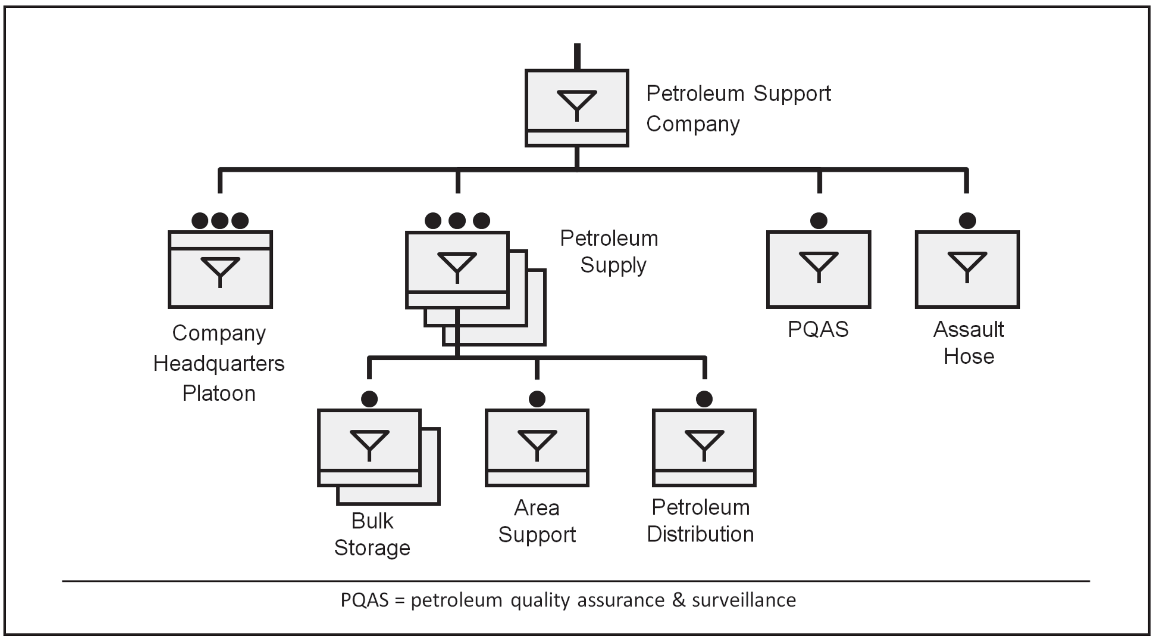

Figure 3-3. Petroleum support company

QUARTERMASTER PETROLEUM SUPPORT OPERATIONS

3-21. Coordinates and tasks the operations of a petroleum support company. Normally assigned to a petroleum support company (50K Bags or 210K Tanks), it is dependent on the company headquarters for administrative, sustainment, and field feeding support, and the equipment and maintenance support platoon for unit maintenance support.

3-22. This unit is employed in the corps or theater support area to provide coordination and tasking for company petroleum mission operations. Normally there is one support operations section per petroleum support company (50K or 210K Tanks).

3-23. This unit has a support operations section which directs, coordinates, and monitors receipt, storage, and issue of bulk petroleum, including the delivery of bulk fuels by organic fuel dispensing vehicles to local high-volume use customers. Coordinates the control, purification, storage, and distribution of potable water. This section is responsible for planning of all operations to comply with national, state, local, and host nation environmental protection laws.

QUARTERMASTER PETROLEUM SUPPORT PLATOON (50K TANK) AND (210K TANK)

3-24. Provides general support to brigade and echelons above brigade on both a direct and area support basis. Normally assigned to a petroleum support company (50K or 210K Tanks), it is dependent on the company headquarters for administrative, sustainment, and field feeding support, the equipment and maintenance support platoon for unit maintenance support, and the support operations section for operational direction of the platoon.

3-25. This unit is employed in the corps or theater support area to provide coordination and tasking for company petroleum mission operations. Normally there is one support operations section per petroleum support company (50K or 210K tanks). There are normally three petroleum support platoons per petroleum support company (50K bag).

3-26. This unit has the following elements:

- The platoon headquarters provides daily inventories, quality surveillance, and coordination of transportation support based on customer requirements.
- Tank Farms (x2) provide general support mission capability and can store 600,000 gallons (210K Tanks = 1,680,000 gallons) at one location or 300,000 gallons (210K tanks = 840,000 gallons) each at two locations, utilizing 50,000 gallon bags and two Fuel System Supply Points (FSSPs). They can receive and issue up to 400,000 gallons of bulk petroleum.
- Area support section provides direct support mission capability and can store up to 120,000 gallons of bulk petroleum at one location and 60,000 gallons when at two locations. It can receive and/or issue in any combination up to 120,000 gallons daily.
- Distribution section provides local delivery and fuel services with its five 5K tankers and four tank and pump units. It can distribute 48,750 gallons of fuel daily based on 75 percent availability of fuel dispensing vehicles at two trips per day. It can also establish and operate four hot refueling points using one Advanced Aviation Forward Area Refueling System systems for transitory aircraft.

3-27. The company headquarters provides mission command, administrative, sustainment, operational, and field feeding support, and field level maintenance management to the petroleum support company. Normally assigned to a petroleum battalion or a CSSB, the company is normally located within a CSSB or echelons above brigade. There is one per petroleum support company.

3-28. This unit has the following elements:

- Company headquarters provides mission command, administrative and sustainment support to the company and any attached elements operating within the company.
- Maintenance section provides field level maintenance management, direct maintenance supervision of the company's subordinate units, equipment repair, and vehicle recovery for the company.
- Operations section comprised of Soldiers and non-commissioned officers from across all major Quartermaster occupational specialties provides subject matter experts to complement the first sergeant.
- Field feeding section provides field feeding for the company. This section can provide remote field feeding support to one site using an assault kitchen.

QUARTERMASTER PETROLEUM SUPPORT PLATOON (50K BAG)

3-29. The petroleum support platoon receives, stores, issues, and distributes (local haul) bulk petroleum to assigned customer units on an area basis. Normally assigned to a petroleum support company or task organized to company-level sustainment headquarters. This unit is dependent on the company headquarters for all normal unit-level support and Engineer support for site preparation.

3-30. The petroleum support platoon is a modular sustainment unit which may operate independently, or as part of a larger unit within a sustainment brigade area of operations. It provides direct and area support to all units within a specified area of operations. It offers full-spectrum POL support that is deployable independent of the parent organization. Normally, three are assigned to a petroleum support company. However, each platoon is capable of operating at a geographically remote location.

3-31. This platoon has the following elements:

- The platoon headquarters provides technical guidance and supervision, daily inventories, quality surveillance, and coordination of transportation support based on customer requirements.
- The bulk storage section (x2) provides general support mission capability of 600,000 gallons of bulk petroleum. This section contains two separate 300K FSSPs, with each location utilizing 50,000 gallon bags, and can receive and issue up to 400,000 gallons of bulk petroleum daily.
- The area support section provides direct support mission capability. This section can store a 120K FSSP and two tank and pump units mounted on medium trucks and trailers for retail issue of petroleum to support units. It can receive and/or issue in any combination up to 120,000 gallons daily.
- The distribution section consists of 5,000 gallon tankers (x5) and medium tractors (x5). The distribution capability of 48,750 gallons of fuel daily, based on 75 percent availability dispensing vehicles at two trips per day.
- The maintenance section attaches a company field maintenance section to augment their capability or perform field maintenance for the platoon when operating independently.

PETROLEUM PIPELINE OPERATING PLATOON

3-32. The pipeline platoon is a modular sustainment unit which may operate independently, or as part of a larger unit within a area of operations. It provides a early entry pipeline capability within a specified area of operations. It offers full-spectrum POL pipeline support that is deployable and independent of the parent organization. Normally, one is assigned to a petroleum support company. However, each platoon is capable of operating at a geographically remote location. The platoon is capable of operating a 45-mile pipeline in the early entry phase of operations, usually employed as a subordinate platoon of a Petroleum Support Company

QUARTERMASTER ASSAULT HOSELINE AUGMENTATION TEAM

3-33. . This team establishes and maintains an assault hoseline connecting tank farms to other tank farms or high volume users. Normally assigned to a petroleum support company (50K or 210K Tanks), it is dependent on the company headquarters for administrative, sustainment, and field feeding support, the equipment and maintenance support platoon for unit maintenance support, and the support operations section for operational direction of the platoon. This unit may require engineer support to overcome obstacles along the hoseline trace. There is normally one per petroleum support company (50K or 210K Tanks).

3-34. This unit has an assault hoseline augmentation team with four hose-lines (otherwise called assault hose-lines) and 15 Soldiers (three per hoseline,~~+~~ two mechanics, and ~~+~~ one section chief). Each hoseline has 2 1/2 miles of collapsible four-inch hose packed on hose reels, uses a 350 gallon per minute (GPM) pump, and can distribute approximately 420,000 gallons of bulk fuel per day (20 operational hours and four hours maintenance downtime).

QUARTERMASTER PETROLEUM LIAISON TEAMS

3-35. These teams provide liaison service between supported units, host nation petroleum activities, DLA-Energy, and the petroleum section of the TSC/ESC and/or sustainment brigade support operations office. The petroleum teams operate in and support an entire geographic area of responsibility. The teams provide the following support:

- Communicates available bulk petroleum data to higher headquarters.
- Determines mode of transportation requirements for bulk petroleum shipments from non-U.S. military activities to U.S. forces.
- Determines by on-site inspections the equipment required to be compatible with existing U.S. Army equipment.
- Insures proper quality surveillance procedures are used to meet U.S. military standards.

3-36. This team has a petroleum liaison team, which provides liaison and coordination for bulk petroleum support between U.S. forces, allied forces, and host nations.

PETROLEUM QUALITY ANALYSIS TEAM

3-37. The Team operates a petroleum laboratory used to perform complete specification and procurement acceptance testing of petroleum products received from supported units. Normally assigned to an aviation support battalion or CSSB, this team is dependent on the assigned unit for unit-level support, administrative support, personnel services, and maintenance.

3-38. This unit provides technical assistance for handling, storing, sampling, identifying, and performing quality evaluation of petroleum products and their containers for all U.S. and allied forces on an area support basis; provides petroleum quality surveillance testing under field conditions; and quality surveillance (B-2-level) testing on ground and aviation fuels, and limited B-level testing on packaged petroleum products, using data to make recommendations for proper use, reclamation, and disposal of the product. The petroleum quality analysis system – enhanced lacks the capability of testing for existing gum and copper corrosion.

3-39. This team has a petroleum quality analysis team, which ensures POL products meet specified physical and chemical properties, conducts B-3 level testing in accordance with the current MIL-STD 3004 on kerosene-based (fuel propellant) JP-5, JP-8, JET A, JET A-1, and diesel military mobility fuels.

BRIGADE COMBAT TEAMS

3-40. The distribution company of the BSB has a petroleum platoon capable of receiving, storing and issuing petroleum to the supported brigade. Generally, this will all be accomplished using mobile storage. If the BSB requires non-mobile storage of petroleum to be able to provide petroleum support to the brigade, the BSB support operations officer must request the non-mobile storage assets from the sustainment brigade. The BSB, brigade staff, and the sustainment brigade must consider the appropriate support or command relationship, to include duration, the non-mobile storage assets will have with the BSB. Once the non-mobile petroleum storage assets are on-site, the BSB must conduct complete coordination with the forward support companies and the brigade to ensure a complete understanding of the non-mobile storage support capability and requirements. The BSB petroleum platoon within the distribution company will also have a limited petroleum fuel testing capability.

3-41. The forward support company will have a petroleum unit capable of receiving, mobile-storage and issuing petroleum to its supported battalion. The petroleum fuel testing capability at this level is limited to a test for water contamination.

COMPOSITE SUPPLY COMPANY

3-42. The bulk storage capability that supports the BCT resides in the composite supply company which is task organized under a CSSB. The composite supply company provides a base capability to the division that can be augmented with additional fuel assets based on battlefield requirements.

3-43. The composite supply company's mission is to provide bulk petroleum quality assurance, storage and distribution to the brigade combat team as well as area support to units operating in the division area. It has the capability to provide bulk fuel storage with 300k and 120k FSSPs up to 420K. The composite supply company can distribute locally up to 95k bulk fuel in M969s, M978s, and tank rack modules. Petroleum transportation assets residing within the composite supply company are required to support competing fuel missions but can be used to augment brigade BSBs with the additional fuel assets. The composite supply company requires assets from the composite transportation company or other transportation units to distribute mobile fuel storage systems. The petroleum quality analysis system which resides in the composite supply company's fuel and water platoon provides direct support quality assurance and testing capabilities to the BCT and on an Area basis.

3-44. There is also a composite supply company that resides in the CSSB located in the Corps area. Its mission is to provide bulk petroleum quality assurance, storage and distribution on an area basis and it is capable of supporting the CSSB operating in the divisional area.

PETROLEUM EQUIPMENT

3-45. The following section describes the types of petroleum equipment used during operations and gives a brief description of its employment.

PIPELINE/HOSELINE

3-46. Petroleum units utilize hose-lines and/or pipelines for use over short and long distances to replace or supplement vehicle delivery. This reduces the number of trucks on the main and secondary supply routes while ensuring that petroleum requirements are met efficiently and effectively. These lines must be patrolled sufficiently to reduce and mitigate sabotage and theft. Generally, hose-lines can be installed rapidly and be in an operational condition in much less time than pipelines. Pipelines offer durability and the capability to operate at higher pressures meaning pump stations can be further apart.

VEHICLE

3-47. Vehicles and trailers specifically designed to receive, transport and off-load or issue petroleum fuels are used throughout the theater at all levels. These will incorporate safety features required for use with liquids such as baffling in the tanks to mitigate product movement in transit. These will be designed to carry fuel quantities appropriate for the mission anticipated for the vehicle. Vehicle missions include line-haul, bulk fuel dispensing, support of refuel-on-the-move (ROM) and aviation refueling missions as well as retail issue into ground vehicles.

STORAGE AND ISSUE OPERATIONS

3-48. Storage systems generally use collapsible fabric tanks (which can come in various storage capacities) interconnected by short hose sections with pumps, filer separators and other associated equipment necessary for operation. Large systems are used to supplement theater storage requirements and issue to linehaul trucks, pipelines or hose-lines. These systems can be special purpose equipment sets designed for aircraft refueling or for use with ground vehicles.

3-49. Storage operations are used to ensure that adequate supplies are kept on-hand ready to use. Depending on the purpose of the storage, the quantities stored may vary greatly. It is extremely important that the status of all storage tanks, to include collapsible fabric tanks, is tracked on a daily basis. This information should be reported to higher headquarters from the operating unit as it impacts the ability to meet theater requirements for storage and distribution. In addition, any equipment problems must be properly documented on quality deficiency reports in order to ensure that the specifications to which military equipment is designed and manufactured meets operational requirements and to provide the Army the ability to hold contract manufacturers accountable for defective equipment manufacturing.

EQUIPMENT MAINTENANCE

3-50. Equipment maintenance, to include preventative maintenance checks and services and regularly scheduled services are among the most important tasks to ensure mission success. Most equipment has established routine inspection intervals. Equipment in storage also requires inspections and services. These inspections can be incorporated with unit training to ensure it remains operational.

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Chapter 4
Army Petroleum Systems

This chapter covers Army Petroleum Systems that support the Army's petroleum mission. It includes a brief description of each system. Additionally, a section on equipment maintenance is included to clarify the responsibilities for maintenance at the various enlisted skill levels. Understand that individual Soldier responsibilities are determined by many factors and that these guidelines are general in nature. A section is also included that briefly describes the black, red, amber, green rating system for collapsible fabric tanks. This same rating system can be expanded to include other petroleum equipment to simplify the reporting process.

SECTION I– PIPELINE AND HOSELINE

4-1. The Inland Petroleum Distribution System (IPDS) is used to interface with an existing fuel source, such as a refinery, or with the Navy's OPDS. It is very light in weight and is easily deployable. Petroleum planners at all levels should be familiar with the capabilities and employment of this system for use during early entry operations and undeveloped theatres (a theater that has little, or no, host nation support or resources).

INLAND PETROLEUM DISTRIBUTION SYSTEM

4-2. Engineers install the aluminum pipeline and pump stations. An engineer construction company can install 1 to 3 miles of aluminum pipe in 24 hours. Quartermaster pipeline and terminal operating units operate and maintain the pipeline and pump stations once they are installed. The IPDS can start at the beach termination unit and run as far inland as practical. It can also start at a TPT or commercial facility.

4-3. The aluminum pipe is packaged in international standards organization (ISO) shipping containers in five-mile sets. It takes 13 ISO containers to transport five miles of pipe with all the related valves and fittings. Pump station intervals depend on system hydraulics. The normal interval on level ground is 15 miles. The system is modular in design and can be tailored for location of operation. Basic components are pipeline, pump stations, and special assemblies.

SECTION II – STORAGE AND ISSUE SYSTEMS

4-4. Petroleum storage and issue systems are found at all echelons and can be employed in multiple configurations. This section lists the systems currently in the Army inventory and gives a brief description of each.

TACTICAL PETROLEUM TERMINAL (TPT)

4-5. TPTs are the storage pieces of the IPDS. They can operate with a pipeline (receiving fuel from and issuing it to a pipeline) or as stand-alone equipment sets receiving fuel by barge, rail car, or tank truck and making bulk issues as necessary. The TPT has no retail capability and cannot be used for that purpose. A TPT can consist of one or more fuel units. When it is used with a pipeline, a pipeline connection assembly is required. The pipeline connection assembly is packed in five 20-foot ISO containers.

FUEL SYSTEM SUPPLY POINT (FSSP)

4-6. The FSSP is the Army's primary fuel storage and distribution system below theater level . It is used to receive, store, and issue any fuel the Army uses, both aviation and ground. The FSSP is a complete, containerized system issued in different fuel storage sizes depending on unit mission. The sizes are as follow:

- 120K – Six 20K Tanks
- 300K – Six 50K Tanks
- 800K – Four 210K Tanks

4-7. The 120K and 300K systems come with 350 GPM pumps and filter-separators, various receipt points and various issue points. The 800K system uses 600 GPM pumps and 350 GPM filter-separators (two connected in parallel for up to 700 GPM) and has both receipt and issue points. The system comes with enough discharge and suction hose to install it under most conditions. The 800K systems may be part of Army Preposition Stocks (APS).

4-8. The FSSP is versatile and can be employed in many different configurations and with varying equipment. It can be set up with any number of collapsible fabric tanks to support the mission, ranging from one tank supplied with the system to all of the tanks. When needed, additional tanks can be used to increase the storage capability of the system.

4-9. It takes an area approximately 100 square yards (the area of two football fields) to set up and operate these systems. Depending on terrain, soil, and climate conditions, engineer support may be required for site development/improvement.

ADVANCED AVIATION FORWARD AREA REFUELING SYSTEM

4-10. The Advanced Aviation Forward Area Refueling System (figure 4-1) is used to refuel rotary wing aircraft in remote locations. Containerized, it can be moved by truck or by utility or cargo helicopters. It uses four 500-gallon collapsible fuel drums as a fuel source and dispenses to four points simultaneously at 55 GPM per point or to two points at 90 GPM per point. All four collapsible fuel drums must be used simultaneously to achieve rated fuel flow.

4-11. The Advanced Aviation Forward Area Refueling System consists of a 225 GPM pump and 240 GPM filter-separator (uses non-standard filters), twelve 500-gallon collapsible fuel drums (four onsite, four being transported to receive fuel, and four being transported back full), four D-1 nozzles, four closed circuit refueling nozzles with open port adapters, and enough hose to connect all of the components for a safe operation. All of the valves and fittings are “dry-break” unisex couplings and are environmentally friendly.

4-12. It takes an open area approximately 100 yards by 50 yards (the area of a football field) to safely operate the system with aircraft entry and exit.

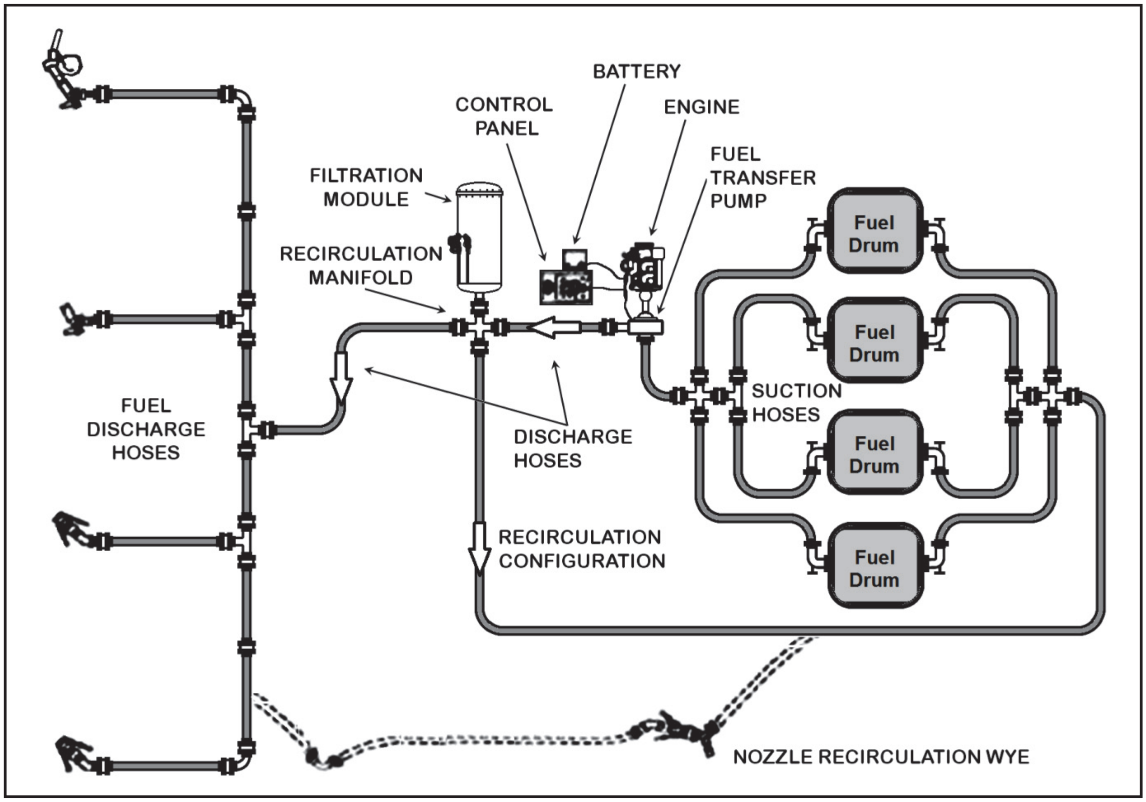

Figure 4-1. Advanced Aviation Forward Area Refueling System

HEMTT-TANKER AVIATION REFUELING SYSTEM

4-13. The HEMTT-tanker aviation refueling system (figure 4-2 on page 4-4) is used to refuel rotary wing aircraft in remote locations. The HEMTT-tanker aviation refueling system can be transported by trailer, high mobility multi-purpose wheeled vehicle, or aircraft. It is designed to be used with the HEMTT – Tanker as the fuel source, pump, and filter-separator. Theoretically, the HEMTT-tanker aviation refueling system should be able to supply 75 gallons per minute to each of its four nozzles simultaneously.

4-14. The HEMTT-tanker aviation refueling system consists only of the hoses, valves, fittings, and nozzles necessary to install the system. All of the hoses and fittings are "dry-break" unisex couplings and are environmentally friendly.

4-15. It takes an open area approximately 100 yards by 50 yards to safely operate the system with aircraft entry and exit.

4-16. In addition to being used to refuel aviation assets, a version of the HEMTT-tanker aviation refueling system has been developed for use as a refuel on the move kit. A fuel source, pump and filter-separator are still required for use.

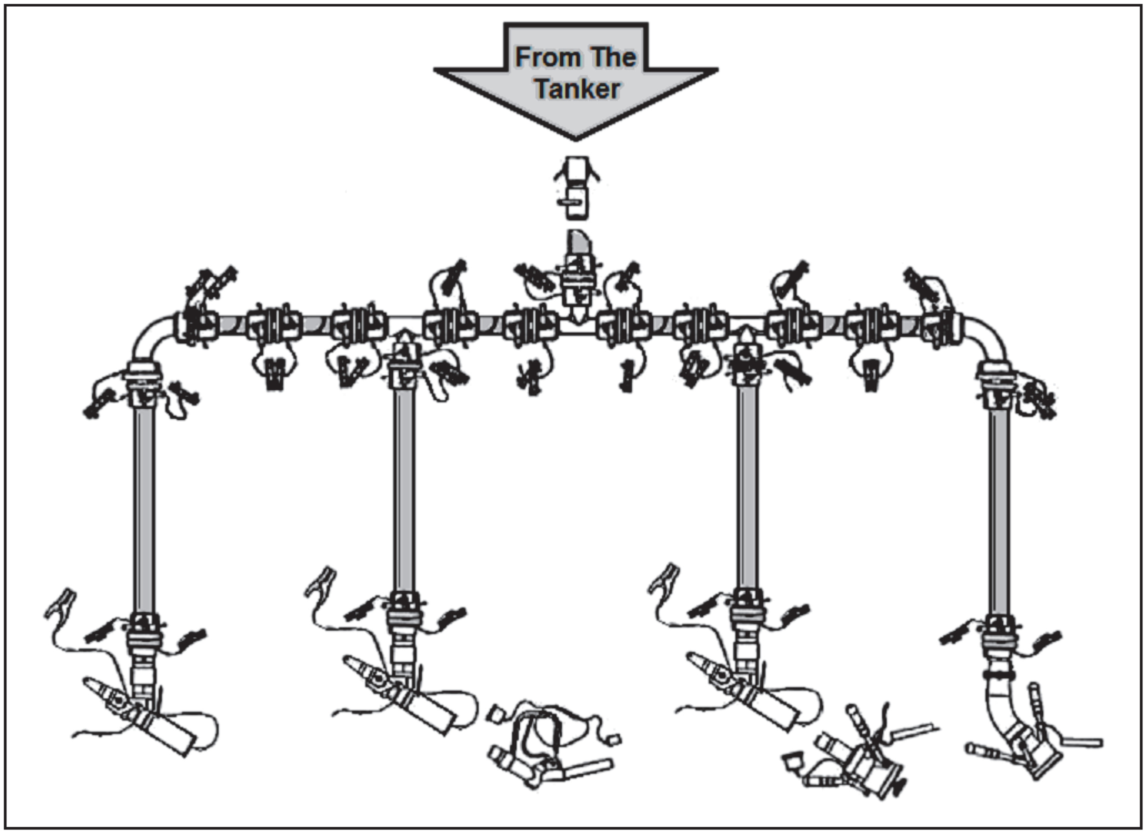

Figure 4-2. HEMTT Tanker Aviation Refueling System

FORWARD AREA REFUELING EQUIPMENT (FARE)

4-17. The FARE is used to refuel rotary wing aircraft in remote locations. Containerized, it can be moved by truck or by utility or cargo helicopters. It uses two 500-gallon collapsible fuel drums as a fuel source and dispenses to two points simultaneously at 50 GPM per point or to one point at 90 GPM. Both collapsible fuel drums must be used simultaneously to achieve rated fuel flow.

4-18. FARE consists of a 100 GPM pump and filter-separator, six 500-gallon collapsible fuel drums (two onsite, two being transported to receive fuel, and two being transported back full), two D-1 nozzles, two closed circuit refueling nozzles with open port adapters, and enough hose to connect all of the components for a safe operation. FARE uses quick-disconnect connections and extra care must be taken to avoid leaks.

4-19. It takes an open area approximately 50 yards by 50 yards to safely operate the system with aircraft entry and exit. For more information related to aircraft refueling, see ATP 3-04.94, *Army Techniques Publication for Forward Arming and Refueling Points*.

LINE HAUL TANK VEHICLES

4-20. Line haul tank vehicles are designed to transport product from sustainment brigade to sustainment brigade. They are used to distribute fuel from larger storage and distribution facilities to smaller storage and distribution facilities (e.g., from a 6,000,000 gallon petroleum terminal to an 800,000 gallon FSSP.) They may or may not have a pump and/or a filter-separator. Generally they hold at least 5,000 gallons of fuel or more.

FUEL SERVICING VEHICLE/TRAILERS

4-21. Fuel servicing vehicles are designed to either refuel consuming vehicles to distribute fuel to smaller fuel servicing vehicles so that they can distribute to fuel consuming vehicles. Fuel servicing vehicles come in sizes from 5,000 gallons and below. They all have pumps and filter-separators as well as hoses and nozzles suitable for refueling individual vehicles and/or aircraft.

SECTION III - REFUEL ON THE MOVE

4-22. The following section discusses planning considerations and the basic concept of refuel on the move. The ROM, when used appropriately, can be very effective tool used most commonly in the offense.

CONCEPT

4-23. The Army's highly mobile force depends on fuel to sustain it on the battlefield more than it ever has in the past. A maneuverable force needs large amounts of fuel in a timely fashion to maintain its offensive posture. Combat vehicles must be refueled efficiently, rapidly, and safely. For combat forces to remain maneuverable, fuel resupply must be flexible and innovative. A ROM operation is normally accomplished as far forward on the battlefield as the tactical situation permits, prior to the tactical assembly area. The doctrinal purpose of ROM is to extend the time that ground maneuver forces can spend on the objective, although ROM can be tailored to other situations as well. When vehicles enter a ROM site for refueling, they receive a predetermined amount of fuel (usually timed) and they move out to return to their convoy or formation. This distinguishes it from routine convoy refueling operations.

WARNING

4-24. Due to safety considerations, normal vehicle refueling is done with the engine off. AR 385-10 states that commanders will apply all normal safety standards to their operations unless it is necessary to change to do the mission. In training situations, changes may be authorized only by the commander. Commanders will evaluate the significance of the assumed risk versus the training benefit. In combat operations, commanders will make decisions based on METT-T and risk analysis.

CONSIDERATIONS

4-25. In planning a ROM operation, METT-T must be considered. Based on these considerations, identify plan, and conduct the type of ROM operations that best support the commander's scheme of maneuver.

MISSION

4-26. The mission drives the need for ROM operations. Since the ROM site is a vulnerable, high value target, consider other refueling options which will do the mission. ROM missions are most often used to support extended moves to a tactical assembly area before an attack or before retrograde moves.

ENEMY

4-27. Known or expected enemy activity in the area of operations and area of interest must be considered. Clear and secure the ROM site before the fuel semitrailers arrive. Risk increases significantly as the ROM gets closer to the forward line of own troops. Consider enemy artillery range when choosing the ROM sites and concealing its operations. Air defense assets should support the ROM site if there is any enemy air threat.

TERRAIN

4-28. A thorough terrain analysis is an essential part of a successful ROM operation. Examine the routes of march, supporting road networks, cover and concealment, the locations of check points, and whether or not the terrain can support loaded fuel semitrailers and high traffic flow. A movement using multiple routes of march may require several ROM sites. Wet, swampy, or restrictive terrain will not support most ROM operations due to the weight of the fuel trailers and the high traffic flow.

TROOPS

4-29. The status of combat vehicle crew and supporting unit soldiers must be analyzed. Do they have enough crew members to operate the issue nozzle themselves and let the driver remain in the vehicle during refueling? Are the soldiers trained on ROM operations? Analyze the forces available to secure the ROM site and perform traffic control.

TIME

4-30. Time must be considered. Consider the time it will take to cover the distances vehicles will be moving; the amount of time available to coordinate, secure, establish, and camouflage the ROM site; the acceptance rate of unit vehicles and the number of minutes of fuel they will receive. Also, determine how far in advance of the main body the security force and fuel semitrailers can deploy while still concealing the projected unit move. The ROM site personnel must ensure each vehicle receives the correct number of minutes of fuel. If not, the following march units will back up.

VEHICLE HOLDING/ MARSHALING AREAS

4-31. Set up these areas at locations before and after the ROM site. Coordinate areas before to the start of the operation. Use the first area (prior to the ROM site) to organize the march column into serials of vehicles equal to the number of refueling points available. Call the vehicles forward out of the holding area one serial at a time to move into position to receive the predetermined amount of fuel. When each serial has received its allotted fuel, it moves to the second holding area (after the ROM site). In the second holding area, organize the vehicles back into their convoy march elements or combat formations.

PRIOR PLANNING

4-32. Plan a contingency for equipment failure. Make sure there is enough room in the site to move equipment. Make the most use of natural cover and concealment. Include a signal system to coordinate the operation. Use signals to start and stop refueling operations, and coordinate the vehicle serials to and from the holding areas. Use the arm and hand signals or flags during the day. Long distances may require radio communications. At night or in low visibility conditions, use chemical light or flashlights for signals.

SAFETY PROCEDURES

4-33. Enforce grounding and bonding procedures for fuel semitrailers, pumps, filter/separators and each refueling point.

4-34. Make sure fuel handlers wear protective clothing (for example, standard combat uniform, hearing protection, goggles, and gloves). With the exception of the standard uniform, other items are normally provided by the organization.

4-35. Locate fire extinguishers at each refueling point and source of fuel (but not so close that they cannot be reached in the event of a fire).

4-36. Place fuel drip pans at each refueling point and fuel source. When draining drip pans, observe fire, safety, and environmental precautions.

4-37. Ensure the fuel spills procedures and equipment should include, as a minimum, sorbents, shovels, and containers. A standard operating procedure should detail equipment and procedures for response in a field environment. Ensure that the standard operating procedure follows federal, state and local requirements.

RESPONSIBILITIES

4-38. For the ROM operation to be expedient and personnel to be proficient on the battlefield, prior coordination and planning must be conducted throughout the chain of command. Successful conduct of ROM operations will require all units to work together. Planning must include both supporting and supported units. It must cover in detail the organization, sustainment, and protection of ROM site(s) and the organization and conduct of the overall operation.

PLANNING STAFFS

4-39. Determine if you need more support requirements to conduct ROM operations and coordinate their requirements with your higher headquarters. Coordinate with higher headquarters for operational and intelligence data. Analyze all factors involved, including the METT-T, to determine the type of refueling operation needed to support the mission. The recommendation is then forwarded to the commander. Select the location for the ROM site based on the METT-T, the ROM configuration, and the established march route. Coordinate ROM security support before setting up the ROM site. Coordinate with the military police for traffic control support at the site. Receive and review estimated fuel requirements and coordinate with the Class III section of the sustainment brigade or TSC. Review and coordinate the vehicle movements into the refueling area to prevent convoy backup.

ROM SITE PERSONNEL

4-40. Set up, perform preventive maintenance checks and services, operate, and retrieve the equipment used in the operation. Ensure safety (for example, grounding, bonding, fire extinguishers, no smoking signs, drip pans, spill equipment is in place and personnel are familiar with procedures). Ensure personnel are familiar and equipped with operational control signals (flags, lights, radio) to be used. Man fuel nozzles to refuel vehicles when convoy personnel (assistant driver or commander) are not available to refuel their own vehicles. Ensure vehicles safely enter and move through the ROM site and receive the prescribed amount/time of fuel.

REFUELING MARCH UNIT

4-41. March unit commanders are subordinate to the ROM site commanders during the refueling operation. Before entering the ROM site, vehicle operators close up vehicle intervals and reduce speeds per standard operating procedure. March units' personnel follow instructions from ROM personnel. ROM site personnel regulate the amount of furling in accordance with the time limits set up. Vehicle passengers (assistant drivers or commander) refuel their vehicles. Vehicle drivers remain in their vehicles. Air guards will continue to observe assigned sectors during the refueling operations.

REFUEL-ON-THE-MOVE EQUIPMENT CONFIGURATION

4-42. ROM is a concept that is equipment independent. As long as the concept is followed, any number of current equipment configurations can be used to do a ROM operation. ROM operations can be employed anywhere on the battlefield where there is a need to rapidly refuel combat vehicles.

ROM

4-43. The ROM kit consists of enough hoses, valves, and fittings to refuel up to eight combat vehicles at the same time. The kit takes care of transporting the ROM. Any cargo vehicle with a payload capacity greater than 1.5 tons can be used. The ROM weighs about 2,900 pounds. It cannot be loaded on the fuel-transporting semitrailer due to the weight limit of the semitrailer. The main fuel source is the 5,000- gallon fuel semitrailer (model, M969s) using onboard pump and filter/separator. The average flow rate at each of the eight nozzles, using the fuel semitrailer, is 35 GPM. The area to set up and operate the eight-point ROM kit is about 550 feet long by 150 feet wide. Multiple tankers can be connected to the ROM kit by means of a Y- or T-fitting and valves. One tanker will be dispensing fuel through the ROM to refuel vehicles. The remaining tanker is backup and ready to replace the issuing tanker when it is empty.

> ***Note***. If conducting multiple tanker operations, fuel should not be received into and dispensed out of the same tanker at the same time. This would only be possible through top loading, which is a safety hazard.

4-44. As a tanker is emptied, the fuel dispensing source is transferred to the backup tanker by the resetting of the values at the Y and/or T. This will allow fuel issues to continue to the combat vehicles. Fuel semitrailers can be shuttled to and from the ROM site to maintain a fueling tanker on-site.

MINI-ROM

4-45. Setting up several Mini-ROMs (four-point ROM), dispersed within the same general area, can reduce the vulnerability of the operation. More security personnel may be required to cover the larger operational area. More traffic control personnel may be required as a result of the multiple ROM sites. Set up a main TCP along the route of march before the mini-ROM sites. Set up communications to coordinate traffic control between the main TCP and the mini-ROM sites. When a march unit reaches the TCP, direct it to break down into sub elements that equal the number of refueling points at each individual mini-ROM site and proceed to a designated location.

COLLAPSIBLE TANK(S) WITH PUMP AND FILTER/SEPARATOR

4-46. Collapsible tankage (for example, 20,000- and 50,000-gallon bags) could be used as the fuel source in ROM operations when the tactical situation does not dictate a highly mobile refueling system and large quantities of fuel are paramount. The ROM system using collapsible tanks should be avoided in forward areas where vulnerability to enemy actions and lack of mobility expose operations to high risk. Planning for ROM operations using collapsible tankage should take into account the additional terrain requirements. The terrain must be level and free of debris. Additional area is required for setting up the equipment (for example, collapsible tank(s), pumps, and filter/separators).

SECTION IV – EQUIPMENT PLACEMENT AND SYSTEM SET UP

4-47. When an area is selected for petroleum equipment to be installed or constructed, it is the petroleum unit warrant officers and non-commissioned officer responsibility to design and install/construct the equipment in the best way to meet the needs of the commander. There is no single “right” way to set up petroleum equipment as they are modular, adaptable and flexible. If the location inhibits the equipment from meeting the commander’s needs in the given area, the warrant officer or non-commissioned officer should inform the commander what impact the area has on the mission (i.e., storage capacity, ability to refuel a number of vehicles, etc.) or what area improvements are needed to allow 100% mission accomplishment.

4-48. The storage tanks of a storage system should be spread out so that in the event of a fire or other mishap the entire storage capacity is not lost. While tanks may be clustered in groups the petroleum system and storage tank placement must be in accordance with mission, enemy, terrain and weather, troops and support available, time available and civilian considerations available-time available and civil considerations.

4-49. Systems are to be set up to meet the command’s petroleum needs in the area provided. There is no specific way a system must be set up as far as design, provided some simple rules are followed:

- Due to the friction that exists between the hose and the fuel (head loss due to friction), the farther the pump is from the fuel source (in feet of hose), the harder it is to prime the pump and maintain the prime once established.
- Because of head-loss due to friction, the further an issue point is from the pump, the less pressure will be available at that point. In a line with multiple issue points, the point closest to the pump will receive the most flow and the farthest point the least flow.
- In a line with multiple issue points being operated simultaneously, the difference in flow rate between those points closest to the pump and those farthest from the pump may be significant. (NOTE: This is important during any time-based refueling operation.)

- Traffic flow should be one way through the refueling site. This helps with security, safety, and mission command within the site.
- Utilize concealment and camouflage as much as possible to include standby crew facilities and sleeping areas.
- Mark the area prominently for ground traffic to discourage unnecessary traffic and hazards, such as someone smoking in an unsafe area or a vehicle entering from the wrong location.
- Berms should be constructed before the system is constructed. If you are unable to do this, construct the system partially while berms are being built for the tanks you have not emplaced. Once these tanks are emplaced, recover the original tanks and construct those berms.
- Pad preparation is the most important part of emplacing a collapsible fabric tank. It must be level and free of holes, hills, ruts, and debris.
- Ensure that the berms are constructed with enough room to walk around and inspect the tank (approximately two-feet when the tank is empty) and for conducting gauging.
- Berms should always be constructed to maintain 100% of the capacity of the enclosed tanks PLUS one-foot of additional height (freeboard). This is in case of a catastrophic failure.

SECTION V – BLACK, RED, AMBER AND GREEN RATING SYSTEM

4-50. It is extremely important that the status of all storage tanks, to include collapsible fabric tanks, is tracked on a daily basis. This information should be reported to higher headquarters from the operating unit as it impacts the ability to meet theater requirements for storage and distribution. In addition, any equipment problems must be properly documented on product quality deficiency report in order to ensure that the specifications to which military equipment is designed and manufactured meets operational requirements and to provide the Army the ability to hold contract manufacturers accountable for defective equipment manufacturing.

4-51. The black, red, amber, green system is a rating system used to easily identify and report the operational capability of collapsible fabric storage tanks see table 4-1 below. Tanks are rated based on damage and leaks and have their storage capacity adjusted accordingly. Leaks are defined as follows:

- Class I: Seepage of fluid (as indicated by wetness or discoloration) not great enough to flow (wet spots).
- Class II: Leakage of fluid (as indicated by wetness) great enough when wiped dry to reappear and flow within 30 seconds. Flow is not great enough to form a puddle on ground.
- Class III: Leakage of fluid great enough to flow from the tank and form a puddle of fuel on ground.

4-52. The tanks are rated as black, red, amber, or green based on the number of the leaks, their location, and size, and the ability to repair the leaks using standard repair kits. Based on the tank rating, the storage capability of the tank is adjusted to reduce risk of a tank rupture or further damage to the tank. TB 10-5430-253-13, *Technical Bulletin for Collapsible Fabric Fuel Tanks*, discusses the black, red, amber, green system and reporting requirements, to include quality discrepancy reports, in complete detail.

Table 4-1: Black, Red, Amber, Green rated allowable fuel quantities

STATUS	210,000	50,000	20,000	10,000	3,000
BLACK (0%)	0	0	0	0	0
RED (50%)	105,000	25,000	10,000	5,000	1,500
AMBER (70%)	147,000	35,000	14,000	7,000	2,100
GREEN (100%)	210,000	50,000	20,000	10,000	3,000

4-53. The black, red, amber, green system can be expanded to incorporate all petroleum equipment and systems into a standardized, theater-wide reporting system. It is important that regardless of the system used, all systems should be reported using the same terms and format to reduce confusion and the spread of misinformation.

SECTION VI – EQUIPMENT MAINTENANCE

4-54. Equipment maintenance, to include preventative maintenance checks and services and regularly scheduled services are among the most important tasks to ensure the success of your mission and the overall tactical mission. No petroleum operations take place without the use of petroleum storage and handling and associated equipment.

- Skill Level -10 Soldiers are expected to know how to perform preventative maintenance checks and services on their equipment correctly; assist in inspecting fabric collapsible tanks in accordance with the black, red, amber, green rating system and other petroleum tanks as required; report changes in status (fully mission capable) to their supervisors; assist in performing scheduled services; perform services and repairs as called for in the maintenance allocation chart; and fill out the appropriate maintenance forms.
- Skill Level -20 Soldiers are expected to be able to accomplish those duties prescribed above, as well as: Assign duties, spot check, supervise, and instruct work techniques and procedures; inspect collapsible fabric tanks in accordance with the black, red, amber, green rating system and document proper forms as required; assure adherence to safety procedures and a safe, clean, and efficient work environment; and review maintenance forms for completeness and correctness.
- Skill Level -30 Soldiers are expected to perform the supervisory duties shown above, as well as: Estimate requirements for personnel, equipment, unit/sustainment level maintenance and repair of petroleum facilities (to include field systems) and equipment; ensure the accuracy of forms generated at lower levels and track and schedule petroleum routine services.
- Skill Level -40 Soldiers are expected to perform the duties shown above, as well as: Oversee platoon maintenance program on petroleum equipment; consolidate tank inspection forms and generate the black, red amber, green report; and coordinate with maintenance support above unit level.

4-55. For most equipment, routine inspections are performed on a daily or weekly basis at most if the equipment is in operation. It is important, however, to note that equipment that is storage requires routine, periodic inspections and services to ensure that it is in and maintains a fully mission capable status. As an example, some collapsible fabric tanks require an inspection each quarter. These inspections can and should be incorporated with unit training and if the item (such as a 20K tank) is a component of a larger end item, all of the equipment can be laid out and inspected at the same time. This can also be combined with routine supply inventories conducted for equipment accountability reasons.

Chapter 5

Multi Service Systems and Equipment

This chapter covers multi service petroleum systems that may be used to support the Army's petroleum mission in certain circumstances. It includes a brief description of each petroleum system. The senior site supervisor or his designee should be capable of establishing criteria for these systems under the black, red, amber, green rating system based on similar Army equipment.

NAVY

5-1. The navy is responsible for delivering fuel to the high water mark of the shoreline. It is not equipped to provide fuel on land. The only Navy fuel equipment likely to be encountered is the vessel designed to transport the fuel and pump it ashore.

5-2. The Offshore Petroleum Discharge System (OPDS) provides bulk transfer of petroleum directly from an offshore tanker to a beach termination unit located immediately inland from the high watermark. Bulk petroleum then is either transported inland or stored in the beach support area (JP 4-03). It is designed to discharge petroleum products to USMC elements, U.S. Army tactical petroleum terminals (TPTs), or U.S. Army inland petroleum distribution system pipelines in accordance with JP 4-01.6, *Joint Logistics Over-the-Shore.*

5-3. The OPDS can be installed up to eight statute miles off-shore and supports ship-to-shore fuel replenishment rates of up to 1.7 million gallons per day for a single product (based on a 20-hour operating day).

5-4. The OPDS ship utilizes dynamic positioning which requires no anchoring system. The vessel can maintain ship position within 2 meters using thrusters and screws.

5-5. The system is installed by Military Sealift Command civilian crews with the assistance of naval support personnel. The OPDS ship provides the hose and pumping capability for a separate fuel tanker which provides petroleum product for transfer to shore

AIR FORCE

5-6. The Air Force is designed to operate from fixed facilities (air bases) and has a limited amount of field equipment suitable to support Army field operations particularly at a forward air field. These consist mostly of trailer mounted pump, filter-separator and hose systems that can be rapidly emplaced to support expedient operations that may not be moved on a daily or weekly basis.

AERIAL BULK FUEL DELIVERY SYSTEM

5-7. The aerial bulk fuel delivery system is essentially a flying fuel point designed to land and either dispense or receive fuel. It can issue fuel using a D-1 nozzle or open port and given advance notice it can also have the closed circuit refueling nozzle available. The fuel is in 3,000 gallon bladders and the total amount of fuel available is dependent on the aircraft used (See table 5-1 for configurations.). It can distribute fuel at up to 350 GPM filtered through a single line.

Table 5-1. Configurations

Standard Aircraft Configurations		
Aircraft	***3K Bladders***	***Total Capacity***
C-130	Two	6,000 gallons

Table 5-1. Configurations

Standard Aircraft Configurations		
Aircraft	***3K Bladders***	***Total Capacity***
C-17	Three	9,000 gallons
C-5	Eight	24,000 gallons

FUELS OPERATIONAL READINESS CAPABILITY EQUIPMENT

5-8. Fuels operational readiness capability equipment is a system consisting of R-18 pumps, R-19 filter-separators, hoses, valves, and R-20/ R21fittings that provide a "hydrant" refueling capability in field environments to aircraft. It can discharge up to 2,700 GPM at its issue points and a total of 400,000 daily (planning factor) or up to 1,000,000 in a surge operation. It is an above-ground, constant-pressure, flow-on-demand fuel issue system. The system can receive from four tank trucks simultaneously; can be configured with any size and number of bladder storage tanks, and/or tied directly into a bulk storage system.

R-14 AIR TRANSPORTABLE HYDRANT REFUELING SYSTEM

5-9. The air transportable hydrant refueling system is an air-transportable refueling system that can be set up to provide field retail refueling at up to 600 GPM for aircraft and vehicles It is equipped with two 50,000 gallon standard fuel bladders, a multi-fuel diesel engine, filter-separator, pressure controls, hoses, single and open port refueling nozzles, and adaptors to create a self-contained aircraft refueling system. It has a 100,000 gallon tank capacity in normal configuration. However, more or less tanks can be used depending on mission.

C-300 GROUND PRODUCTS REFUELER

5-10. The C-300 is designed for operation on hard or improved surfaces at low to moderate speeds. A 4WD C-301 version of the same vehicle is also available for use in more austere conditions.

- Tank Capacity – 1,200 gallons.
- Pump Capacity – 100 GPM.
- Issue Coupler – 2 ½-inch faucet/over-wing-type nozzle.
- Receipt Coupler – Three-inch dry break coupler.

R-9 TANK TRUCK AIRCRAFT REFUELER

5-11. The R-9 is designed for operation on hard surfaces at low speeds under 25 miles per hour within the air base area. Maintenance problems should be anticipated if converted to over-the-road haul at speeds up to 55 miles per hour.

- Tank Capacity – 5,000 gallons
- Pump Capacity – 600 GPM
- Issue Camlock Coupler – Standard pressure 2 ½-inch, open port
- Receipt Camlock Couplers – Refilled via 2 ½-inch standard pressure bottom loading adapter

R-11 TANK TRUCK AIRCRAFT REFUELER

5-12. The R-11 is designed to be driven on improved roads and on a limited basis on unimproved roads. Refueler road speed, fully loaded, is 60 miles per hour depending on road and weather conditions.

- Tank Capacity – 6,000 gallons.
- Pump Capacity – 600 GPM.
- Issue Camlock Coupler – standard pressure 2.5 inch, open port.

Receipt Camlock Coupler – Refilled via 2 ½-inches standard pressure bottom loading adapter.Bulk Fuel Storage System, 200,000 Gallons

5-13. The 200K bulk storage system (UTC - JFAXC) consists of one R-22, 600/900 GPM pump one FFU-15E 600 GPM filter-separator, four 50,000 gallon standard DOD fuel bladders a 35 psi hose end pressure regulator; standard pressure nozzle, hose sections, and valves to permit off load or issue of fuel.

- Tank Capacity – 200,000 gallons (Four each, 50K bladders).
- Pump Capacity – 600/900 GPM.
- Issue Camlock Coupler – Three-inch male.
- Receipt Camlock Coupler – Four-inch female.

MARINE CORPS

5-14. Like the Army, the Marine Corps use the ability to alter fundamental system configurations, and interchangeability of components which allows the creation of limitless combinations of tailored systems to meet mission requirements.

Amphibious Assault Fuel System

5-15. The amphibious assault fuel system is the largest Marine tactical fuel system. It is used to receive, store, transfer, and dispense all types of fuel. It is similar to the Army fuel unit in the IPDS. The amphibious assault fuel system supplies bulk fuel to all elements of a Marine air-ground task force including distribution by hoseline to airfields. Care must be taken to segregate different types of fuel. The system can receive fuel from offshore vessels, railcars, tank trucks, bulk storage tanks, pipeline/hoseline, and drums. Fuel is stored and can be transferred to another storage site or dispensed to individual containers, vehicles, tank trucks, and other fuel systems. Six assemblies compose the :

- Beach unloading assembly.
- Receiving assembly.
- Two booster stations.
- Two adapting assemblies.
- Two dispensing assemblies.
- Six tank farm assemblies.

5-16. Each amphibious assault fuel system has one beach unloading assembly used for receiving fuel during ship-to-shore operations. Two booster station assemblies in each amphibious assault fuel system are used when the distance between storage sites is greater than the pumping distance the storage site pumps are capable of pumping. The Amphibious Assault Fuel System storage capacity comes from the six tank farms. One receiving assembly in each Amphibious Assault Fuel System provides the capability to receive fuel from multiple sources. Two dispensing assemblies in each Amphibious Assault Fuel System provide the capability to dispense fuel.

5-17. The amphibious assault fuel system has two adapting assemblies to make the system compatible with commercial and other Services' fuel systems. Versatility is an important part of the Amphibious Assault Fuel System, which can be deployed as a whole or tailored to meet mission requirements.

5-18. The amphibious assault fuel system storage capacity is 1.12 million gallons made up from its six tank farms. The amphibious assault fuel system has approximately five miles of six-inch assault hose and uses 600-GPM pumping capabilities. Using quick-connect, camlock fittings, the Amphibious Assault Fuel System can be assembled without tools and is compatible with the other Marine Corps tactical fuel systems.

Tactical Airfield Fuel Dispensing System

5-19. The tactical airfield fuel dispensing system is similar in design to the amphibious assault fuel system. This system is used for receiving, storing, transferring, and dispensing aviation fuel in support of airfields. This system is air transportable and compatible with other marine tactical fuel systems. The tactical airfield fuel dispensing system can receive fuel from almost any source with the appropriate adapters. Fifty-five gallon drums may be defueled using the drum-unloading portion of the tactical airfield fuel dispensing system. With the single fuel on the battlefield concept, the tactical airfield fuel dispensing system can supply aviation and ground fuel for airfields.

5-20. The tactical airfield fuel dispensing system consists of six 20,000-gallon and four 50,000-gallon collapsible tanks for a storage capacity of 320,000 gallons. Each tactical airfield fuel dispensing system has seven pumps (either 350 or 600 GPM.) With its designed pumping rate and equipment to set up 12 dispensing points, the tactical airfield fuel dispensing system has a multi-plane fueling capability. The tactical airfield fuel dispensing system may also be used to replenish tank vehicles. Filtration of the fuel to meet aircraft requirements is accomplished using filter-separators and fuel quality monitors. The tactical airfield fuel dispensing system is used for hot or cold aircraft refueling.

HELICOPTER EXPEDIENT REFUELING SYSTEM

5-21. The helicopter expedient refueling system is designed to support helicopter operations in advanced areas and remote sites. It is normally used at forward arming and refueling points. Equipped with two-inch hoses and adapters, the helicopter expedient refueling system is compatible with other Marine Corps TFSs. The helicopter expedient refueling system has 18 each 500-gallon collapsible drums and three 3,000-gallon collapsible tanks. The helicopter expedient refueling system has four 100/125 gallons per minute pumps and enough components to set up four refueling points. It may be deployed as a whole or in part to meet operational requirements.

EXPEDIENT REFUELING SYSTEM

5-22. The expedient refueling system is designed to support ground vehicles in forward positions. It is very similar to the Army FARE system. It is normally used with 500-gallon collapsible fuel drums or 3,000-gallon collapsible fuel tanks. It consists of either a 100 or 125 gallons per minute pump with various two-inch hoses and fittings for two refueling points. All components within the expedient refueling system have two-inch couplings. The expedient refueling system does not have filtration equipment and should not be used for aircraft refueling.

MARINE CORPS LIQUID STORAGE, TRANSPORTING, AND DISPENSING SYSTEM

5-23. The Marine Corps liquid storage, transporting, and dispensing system is used to store, transport, and dispense fuel. The system is transportable by air or ground. Components of the fuel system are a fuel pump module and five fuel tank modules. The modules form a fuel distribution source that can be transported as a unit or individually. The system consists of:

- 125-GPM pump, 100-GPM filter-separator, 100-GPM fuel quality monitor.
- Meter assembly.
- Hose reel.
- Five 900 gallon fuel tank modules.
- Three of the modules and can be connected to form a standard 20-foot ISO container compatible unit.

M970 FUEL SERVICING SEMI-TRAILER

5-24. The M970 5,000-gallon mobile refueler provides aircraft refueling/defueling and over-the-road transportation of bulk fuel.

TACTICAL PETROLEUM LABORATORY, MEDIUM

5-25. The tactical petroleum laboratory, medium provides the essential testing components integrated into an ISO container to monitor the critical physical and chemical characteristics of aviation and ground fuels. There are 16 tests that can be conducted in accordance with the American Society for Testing and Materials. 100LL aviation gasoline, JP-5, JP-8, diesel, and their commercial grade equivalents can be tested for composition and quality against minimum standards as specified in the current MIL-STD 3004. The tactical petroleum laboratory, medium can also test captured fuels.

AVIATION REFUELING CAPABILITY

5-26. The aviation refueling capability is a 5,000-gallon commercial refueler modified for Marine Corps use. The aviation refueling capability provides a mobile aviation refueling capability to the Marine Aircraft Wing. The aviation refueling capability has been procured through a General Services Administration contract. The fielding of the aviation refueling capability and a subsequent off-road aviation refueling system enable the Marine Corps to phase the aged M970 semitrailer out of the inventory. The M970 was fielded in the 1970s, with a follow on buy in 1994, and is experiencing readiness problems. The aviation refueling capability provides the M970 basic capabilities with several technological advancements; however, the aviation refueling capability has limited off-road capabilities.

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Appendix A
Fuel Testing

AMERICAN PETROLEUM INSTITUTE GRAVITY

A-1. The American Petroleum Institute gravity is one of three measures of density (mass per unit volume at a specified temperature) used in the petroleum industry. The American Petroleum Institute I gravity scale was developed to eliminate the problem of working with decimals associated with specific gravity. An American Petroleum Institute gravity of 10 is equal to a specific gravity of 1.000. As the American Petroleum Institute gravity goes up, its corresponding specific gravity goes down. American Petroleum Institute gravity, corrected to 60oF, is needed in order to select volume correction factors to be used in fuel accounting procedures. Used as a quality control measure, a change in American Petroleum Institute gravity means a change in composition of the product. For example, when the American Petroleum Institute gravity of a product rises more than 0.5, the cause is usually contamination by a lighter petroleum product. A drop in American Petroleum Institute gravity is generally caused by contamination with a heavier product. Results that vary more than 0.5 indicate a problem, and further tests must be performed to determine the cause. Always know the temperature to which the American Petroleum Institute gravity corresponds.

APPEARANCE/WORKMANSHIP

A-2. This determination is made by observation of the fuel in a clear container. Depending on the product, it will be clear (free of suspended matter or particles), bright (sparkle in transmitted light), homogeneous (uniformly mixed), separated (stratified or bleeding), or has visual sediment or water. To make these determinations, care should be taken that nothing is overlooked. Solid and liquid contamination can lead to restriction of fuel metering points, improper seating of inlet valves, corrosion, fuel line freezing, gel formation, filter plugging, or failure to lubricate. Product containing visual sediment and water should be allowed to settle and then filtered before use.

AQUA-GLO

A-3. The Aqua-glo test measures very small concentrations of free water that cannot be seen with the naked eye. Water can become a petroleum contaminant at any stage from the refinery to ultimate use. Extreme care must be taken to eliminate it from fuel. Water in aviation fuels can freeze and form ice. The resulting ice can clog on-board fuel filters and prevent fuel flow to the engine. For this reason, water is generally limited to 10 parts per million, maximum. If the result is higher, a resample should be taken and tested. If a resample fails, the fuel distribution system should be evaluated for proper settling times and filter elements checked. Water in diesel fuels can cause severe corrosion in cylinders and stop a diesel engine. Fuel line freezes can occur in ground equipment as well as aircraft.

CLOUD POINT

A-4. The cloud point of a diesel fuel is the temperature at which the fuel first begins to freeze. Under low-temperature conditions, paraffinic constituents of a fuel may be precipitated as a wax. The cloud point of a fuel is a guide to the temperature at which it may clog filter systems and restrict flow. Contamination with a heavier product can raise the cloud point. When deployed, a property called cold filter plugging point is used in place of the cloud point. For the cold filter plugging point test, the temperature at which sufficient wax builds up to clog a standard fuel screen is reported. The cold filter plugging point temperature is usually lower than the cloud point, but not as low as the pour point.

COLOR

A-5. In refining, a color test is used to determine the uniformity of a product batch. Once the product is in the distribution system, a color test is used as a quick check for deterioration and contamination. If a color test reveals a color darker than expected, the test may indicate contamination by a heavier product or deterioration due to age. If a test reveals a color lighter than expected, the test may indicate contamination by a clear or straw-colored product. Color may be reported either as a visual color (for example, “straw”, “water white”, “yellow”) or as it relates to a reference scale. Two examples of a reference scale are the Saybolt Color (used for aviation fuel) or an American Society for Testing and Materials Color (used for diesel fuel). In these tests, the color of a fuel is compared in a device to reference color standards and reported as a numerical digit.

CONDUCTIVITY

A-6. The ability of a fuel to dissipate electrical charges that have been generated during pumping and filtering operations is controlled by its electrical conductivity, which depends upon its content of polar species. If the fuel conductivity is sufficiently high, charges dissipate fast enough to prevent their accumulation and dangerously high potentials at a fuel dispensing point. The use of a static dissipator additive can increase fuel conductivity to safe levels. Moreover, conductivity can be affected by filtering and transferring operations and by temperature changes. For this reason, the fuel sample for the conductivity test is taken close to where the fuel enters the aircraft.

COPPER CORROSION

A-7. This test is a qualitative measure of the corrosiveness of a product. Fuel is heated in the presence of an immersed polished copper strip for a specified period of time at a specified temperature, and any resulting corrosion of the copper strip is rated against a corrosion standard. This corrosiveness comes from the presence of free sulfur or sulfur compounds. When properly refined, these products are non-corrosive, with American Society for Testing and Materials D 130 ratings of 1A or 1B. Test results of greater than 1B indicate the presence of corrosive compounds. This is usually unacceptable; however, in the case of some products, short-term use of the product may be authorized. In bulk storage tanks, corrosion results from H2S being formed in water bottoms and percolating up through the product. Off specification corrosive fuel must be blended with a better, less corrosive fuel to bring it within acceptable limits. Sulfur tests should also be performed to determine the exact amounts of sulfur compounds present.

DISTILLATION

A-8. The distillation test is used to evaluate vaporization characteristics of a fuel as it progresses through initial engine start-up, operation at low and high loads, and at engine operating temperatures. Distillation points of 10, 20, 50 and 90 percent are specified in various ways to ensure that a properly balanced fuel is produced with no undue proportion of light or heavy fractions that will operate property in the engine. The distillation end point and distillation residue excludes any heavy material which would give poor fuel vaporization and ultimately affect engine combustion performance

EXISTENT GUM

A-9. The existent gum is the weight of material left over in a test beaker after the fuel sample is evaporated under test conditions. High gum content indicates that the fuel might cause deposits in the induction system and sticking of intake valves. The existent gum test can tell the user the amount of oxidation that has taken place before the test was performed. Storage tanks that are vented to the atmosphere breathe when temperatures fluctuate. This causes the fuel to oxidize and form gum. Contaminated fuel will show an oily gum; deteriorated fuel will show a dry gum.

FLASH POINT

A-10. The temperature at which sufficient vapors from the fuel are present to ignite the fuel with a flame or hot coil. Flash point is a guide to the fire hazard associated with the fuel. The flash point generally is associated with the lower combustible limit for fuel. If the flashpoint drops by more than 6°F, contamination with a lighter product should be suspected. This should also show up in a lower initial boiling point in the distillation. If the flash point goes up more than 6°F, contamination with a heavier product should be suspected. A higher distillation end point, higher viscosity, and possibly a color change will verify this. To a limited degree, off specification product can be upgraded by blending.

FREEZING POINT

A-11. The freezing point is measured for aviation fuel and is the temperature at which the last wax crystal disappears. Wax and excess aromatic components in fuel raise the freezing point. These components can be present as a result of contamination or poor refining. Modern aircraft fly at high altitudes where temperatures can be as low as - 67° F. At these low temperatures, wax and aromatics can freeze and clog fuel line strainers, shutting off the engine. A fuel failing the freezing point test usually indicates contamination with diesel fuel or fuel oil. This can be confirmed by high distillation end points, oily gum results, and water reaction interface test failures. Fuels failing the freezing point test can be upgraded by blending with on specification product.

FUEL SYSTEM ICING INHIBITOR

A-12. A fuel system icing inhibitor is added to jet fuels to prevent free water from freezing at high altitudes and cold temperatures. As a fuel cools, dissolved water will come out of the fuel and become free water. At the cold temperatures, the free water can freeze and create ice particles, which can block fuel filters. Fuel system icing inhibitor keeps the free water liquid. Fuel system icing inhibitor will drop out of fuel easily when the fuel is in contact with water. Proper quality control of jet fuel requires that contact with water be strictly avoided. In the event of test failure, storage procedures should be evaluated to find the source of the water contamination.

PARTICULATE CONTAMINANT

A-13. The weight of solid contaminants per unit volume obtained by filtering a known volume of fuel through special filter paper and weighing the solid trapped on the paper. From the time a fuel is refined until it is used, it comes in contact with iron, rust, sand, and other solid contaminants. Generally, fuel is allowed to settle and then filtered in order to remove these contaminants. The particulate contaminant test is performed at various distribution locations to determine the effectiveness of the cleaning process. If the test result is too high, an immediate resample should be taken as high results may be due to poor sampling technique. If a resample also fails, the entire system should be evaluated to detect the problem. The high result could be caused by inadequate settling times or unserviceable filter elements.

POUR POINT

A-14. The temperature at which the diesel fuel still flows is the pour point. Below this temperature, the entire fuel volume is frozen. The test is important in determining the use of products in cold climates. The pour point of a petroleum specimen is an index of the lowest temperature of its utility for certain applications. If a product will not pour below a certain temperature, it will have restricted use. Products that have a pour point that does not meet specifications usually are contaminated by a heavier product.

REID VAPOR PRESSURE

A-15. Reid vapor pressure measures the vapors produced by the fuel under test conditions. Vapor pressure must be at a level that will ensure the fuel vaporizes in the carburetor. If the pressure is too high, fuel will vaporize in the fuel line, causing vapor lock, and the engine will not run. Also, fuel in storage with too high a Reid vapor pressure will evaporate excessively. If the vapor pressure is too low, fuel will enter the carburetor as a liquid, causing oil dilution and incomplete combustion. Reid vapor pressure is directly related to temperature. Generally, Reid vapor pressure problems can be solved by blending with an on-specification product.

THERMAL STABILITY

A-16. This test measures the uptake of nitrogen or air and the deposits formed on a test strip under test conditions. Thermal stability is the resistance of fuels to chemical and physical change upon exposure to high temperatures that tend to decompose them. Fuel is expected to perform a cooling function by providing a heat sink; that is, by absorbing the heat generated in high-speed flight. Fuel cannot do this unless it resists decomposition. A coke-like substance forms in thermally unstable fuels and plugs fuels jets and manifolds. Aircraft are routinely exposed to temperatures of -65º to 400ºF. Presence of aromatics and olefin components are restricted in jet fuels because they are less heat resistant.

VISCOSITY

A-17. Viscosity is a resistance to flow of a liquid at a specified temperature. The viscosity of fuels at low temperature is limited to ensure that adequate fuel flow and pressure are maintained under all operating conditions and fuel injection nozzles and system controls will operate down to design temperature conditions. Viscosity can affect significantly the lubrication property of the fuel, which has an influence on fuel pump service life.

WATER REACTION

A-18. In this test, a buffered water solution and fuel are shaken together in a graduated cylinder and the interface of the fuel/water layers is rated for material at the interface. This test is performed on aviation fuels to determine the presence of excess alcohol or aromatic components and to evaluate the presence of surfactants on the fuel/water interface. Aromatics absorb water, and excess amounts of them will cause excess water to be held in fuel. This water will freeze at high altitudes, clogging fuel lines. Surfactants can cause excess sediment and water retention, which causes fuel filter clogging.

Appendix B
Safety Data Sheet

Safety data sheets are published by the manufacturers of chemicals. They give a wealth of information on specific products. These are particularly beneficial when a product contains a mixture of ingredients. The safety date sheet provides you important information about the chemical substance, its hazards, and the procedures to follow to avoid injury and illness. Ensure that all personnel assigned, attached, or working around these chemicals read and fully understand the safety data sheets before they handle any products. The safety data sheet contains the following general sections. See paragraph B-1.

B-1. Safety data sheets are published by each manufacturer as required. Because they are published by so many companies, they may not look identical; however, they do contain all required information in the same sections. These are explained below:

- SECTION 1. PRODUCT IDENTIFICATION – Contains the name of the product, technical and emergency contact information and other information required to identify the product.
- SECTION 2. HAZARDS IDENTIFICATION – These are the ways that short and long term this product can affect individuals.
- SECTION 3. COMPOSITION – The chemical composition of the product
- SECTION 4. FIRST AID MEASURES - The measures that should be taken if any of the hazards listed above present symptoms.
- SECTION 5. FIREFIGHTING MEASURES – The standard flammability classification, flash point, lower and upper flammability limits, auto-ignition temperature, and other pertinent information, special hazards, and firefighting measures.
- SECTION 6. ACCIDENTAL RELEASE MEASURES – The measures that should be taken to stop, control, contain, and clean up accidental spills and/or releases.
- SECTION 7. HANDLING AND STORAGE – Hazards that can occur during handling and storage of the material; actions you can take to mitigate risks and other storage and handling requirements.
- SECTION 8. EXPOSURE CONTROLS AND PERSONAL PROTECTION – Actions you can take to protect yourself and others from unnecessary exposure to the product and other actions you can take to enhance overall safety.
- SECTION 9. PHYSICAL AND CHEMCIAL PROPERTIES (TYPICAL) – Various physical properties of the product that may be of importance in your operation such as water solubility, melting/freezing point, vapor pressure, specific gravity, etc. Understand that these are "typical" of the product overall and the product that you have on hand may vary slightly from that listed.
- SECTION 10. STABILITY AND REACTIVITY – How stable the product is, materials with which it is incompatible, conditions to avoid, and any hazardous products produced by decomposition.
- SECTION 11. TOXICOLOGICAL INFORMATION – A list of the various chemical formulations in the product and the symptoms they can cause when exposed immediately, mid-term, and long-term.
- SECTION 12. ECOLOGICAL INFORMATION – The effects of the product on the environment and how it may move within the environment and be introduced to life forms.
- SECTION 13. DISPOSAL CONSIDERATIONS – Things for you to consider if you dispose of the product or contaminated waste.
- SECTION 14. TRANSPORT CONSIDERATIONS – Department of Transportation requirements for transporting the product on road/railways.

- SECTION 15. REGULATORY INFORMATION – Applicable regulations applying to this product and their requirements for storage and handling of this product.
- SECTION 16. OTHER INFORMATION – Other information the manufacturer has determined may be of interest to you concerning this product.

Appendix C

Flow Conversion Chart

C-1. Table C-1 provides data on converting flow measurements. This is important when operating with and in different countries or systems which require accounting to be kept in different units of measurement.

Table C-1. Flow conversion table

CONVERT	***TO***	***MULTIPLY BY***
Barrels per day	gallons per hour	1.75
	gallons per minute	0.0292
Barrels per hour	cubic feet per minute	0.0936
	cubic feet per second	0.00156
	gallons per minute	0.7
Gallons per hour	cubic feet per hour	0.1337
	cubic feet per second	0.000037
	gallons per minute	0.0166670
Gallons per minute	barrels per day	34.2857
	barrels per hour	1.4286
	barrels per minute	0.02381
	cubic feet per day	192.5
	cubic feet per minute	0.13368
	gallons per day	1,440.0
	liters per second	0.06309
	cubic feet per second	0.002228
Cubic feet per minute	gallons per second	0.1247
	liters per second	0.472
	cubic centimeters per second	472.0
Cubic feet per second	million gallons per day	0.646317
	gallons per minute	448.831
Cubic yard per minute	cubic feet per second	0.45
	gallons per second	3.367
	liters per second	12.74
Liters per minute	cubic feet per second	0.0005886
	gallons per second	0.004403

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Appendix D
Assault Hoseline Hydraulics

This appendix provides the information necessary to provide an understanding of the sequence of events and consideration of installing an Assault Hoseline System. It covers terrain surveys, site considerations and locations, hydraulic profiles, pump station locations, and other considerations.

TOPOGRAPHICAL SURVEY

D-1. Prior to installing assault hoseline system equipment, a thorough study of the terrain is required, using a topographic map supplemented by aerial surveys, maps, photographs, and charts. Based on this survey, the optimum trace is selected and a hydraulic profile of the assault hoseline system is constructed. Using the profile and the hydraulic limitations of the pumps, mark the assault hoseline system trace and the required locations for pump stations, pressure reducing valves, and any other pieces of equipment required to be placed. Items to consider when completing the survey follow:

- Whether the assault hoseline system will operate independently or as part of a large system.
- Expected length of time the assault hoseline system will be required to operate.
- Elevation changes and total distance the assault hoseline system will encounter along its route.

ROUTE RECONNAISSANCE AND SITE LOCATION

D-2. Marking of the assault hoseline system trace and placement of components can be done when conducting the physical reconnaissance. Stakes or other marking devices can be used to indicate the actual path of the assault hoseline system and the location of specific components, as determined by the map recon and hydraulic profile. When selecting a route for the assault hoseline system, consider the following:

- The route should be direct and present a minimum number of obstacles and obstructions.
- A route parallel to a secondary all-weather road is preferable to one along a heavily-traveled road.
- If roadways do not exist or cannot be utilized, select a route that is accessible to vehicles required for laying the assault hoseline system.
- Keep security precautions in mind. Utilize natural camouflage wherever possible and avoid routing the assault hoseline system through populated areas.
- Avoid difficult terrain when possible.

INSTALLATION CONSIDERATIONS

D-3. When installing the assault hoseline system consider the following:

- Plan to locate the junction of two assault hoseline system lengths at installation sites for each pump station.
- Pump stations must be located in accordance with the hydraulic profile. The pump station should be on firm ground and should be as level as possible.
- Pressure-reducing valves must be located in accordance with the hydraulic profile. These valves are placed on the downward side of hills to reduce pressure increases due to gravity.

PUMP STATION SELECTION

D-4. When selecting pump station sites, the location of the lead or first pump station will be determined by the location of the fuel source. Pump stations are intended to be spaced at approximately one mile intervals, assuming that the route is reasonably direct and the terrain is level. However, a substantial rise or fall in elevation along the assault hoseline system route may require adjustment of standard spacing intervals between pump stations. When substantial rise or fall in elevation occurs between two consecutive pump stations, the following pump station movements must be performed:

- If the next downline pump station is substantially higher in elevation than the upline pump station, decrease distance between the pump stations.
- If the next downline pump station is substantially lower in elevation than the upline pump station, increase distance between the pump stations.

D-5. Adjusting distance between pump stations when elevation changes occur assures that the assault hoseline system pressure will be maintained within optimum operational range. Under optimal spacing conditions, the assault hoseline system will deliver fuel to the suction port of each pump station at a pressure of 20 pounds per square inch. Whenever pressure falls below 20 psi, pumping assemblies are designed to begin reducing speed when operated in the electric automatic mode. Therefore, if an upline pump station is substantially lower than the next downline station and the elevation difference has not been offset by spacing adjustment between pump stations, suction pressure at the downline pump station may fall below 20 psi and cause that pump to slow down. This in turn will cause remaining downline pump stations to slow down, seriously degrading overall performance.

GROUND PROFILE CONSTRUCTION

D-6. A ground profile (drawn on graph paper) is needed to determine the location of pump stations. Proper drawing of the ground profile will ensure that the assault hoseline system will perform within its optimal operational range. To construct a ground profile, first obtain a topographical map or other source of material that provides accurate information about terrain along the projected assault hoseline route. Using this information, draw a ground profile of the assault hoseline system route on graph paper as follows:

- Divide the horizontal base of the ground profile graph, figure D-1, into spaces that represent uniform distances, such as 1,000-foot intervals. However, any suitable scale can be used. The ground profile base represents the horizontal distance the assault hoseline system will cross.
- Divide the vertical left-hand edge of the ground profile graph, figure D-1, into spaces that represent uniform changes in elevation, such as 100-foot intervals. Again, any suitable scale can be used. However, the scale must include at least the highest and lowest elevations along the assault hoseline system route.

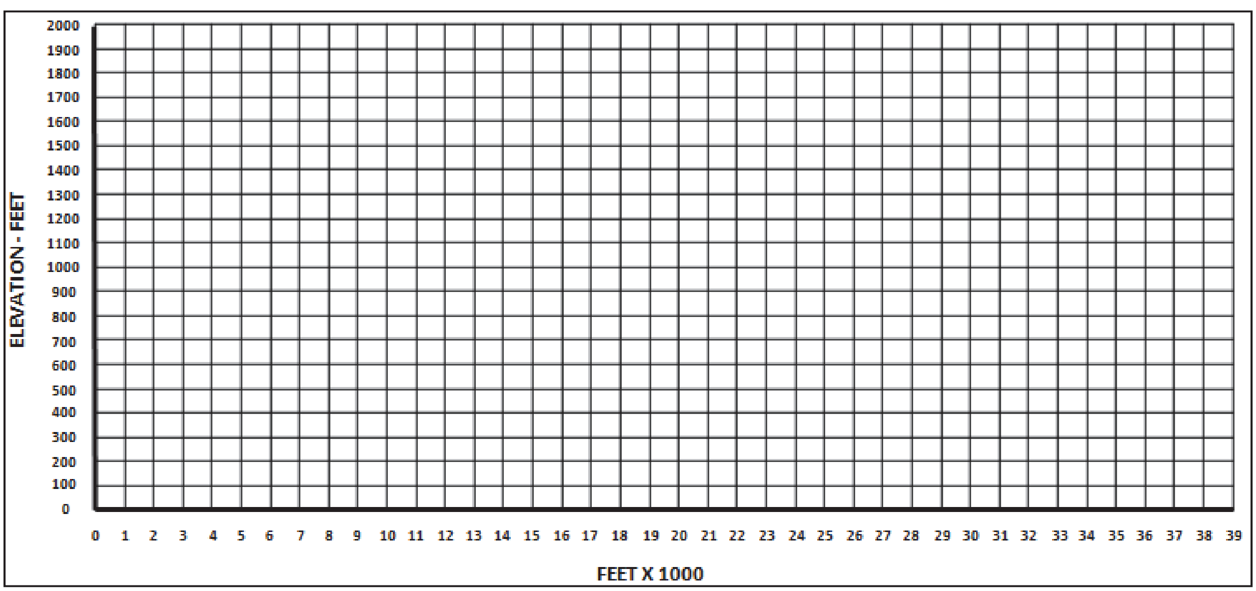

Figure D-1. Graph paper

- At left-hand edge of the ground profile graph, figure D-2, mark a point that represents the lead pump station elevation.

- Continuing across the ground profile graph, Figure D-2, mark points where significant changes in elevation occur along the assault hoseline system route.

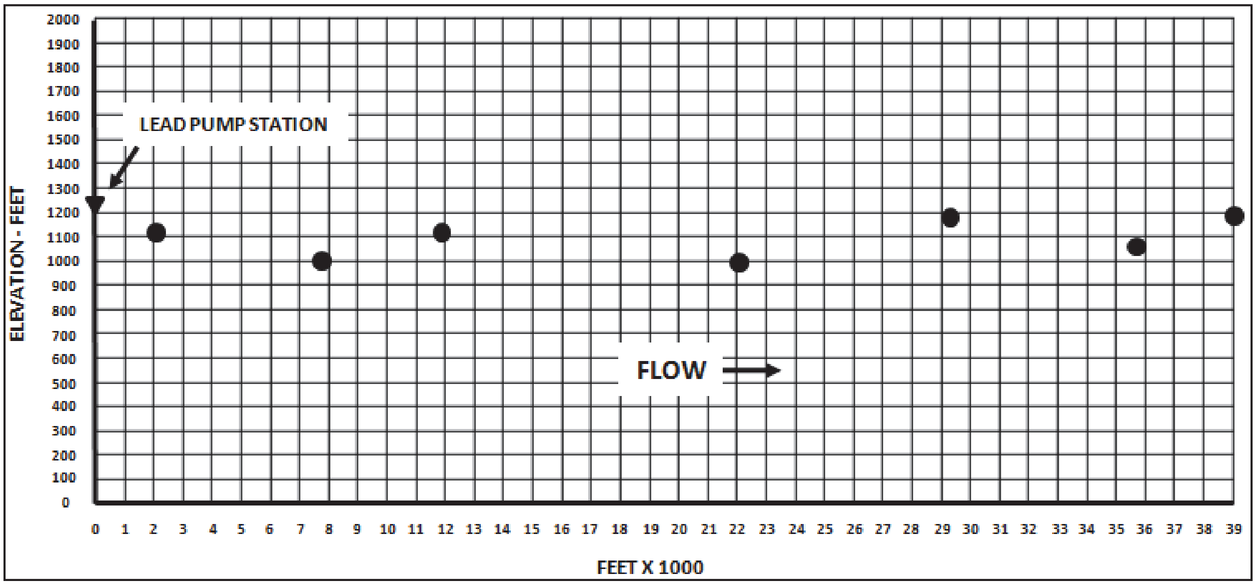

Figure D-2. Elevation changes

- To complete the ground profile, figure D-3, join the points marked on the ground profile graph with a straight line.

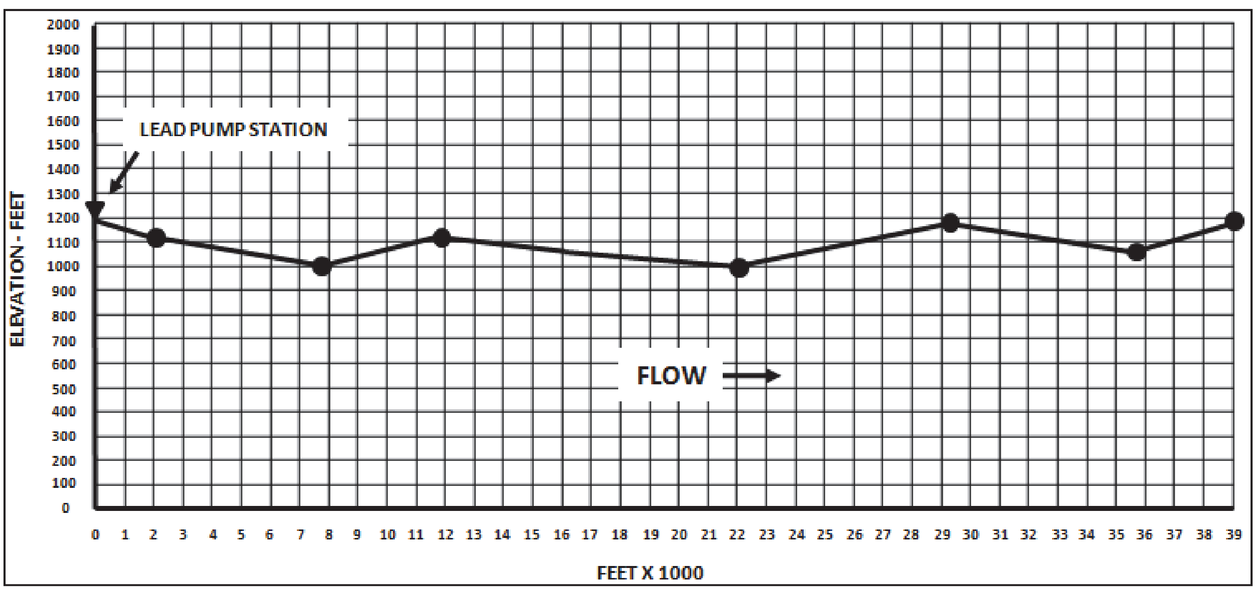

Figure D-3. Ground profile

PUMP STATION TRIANGLE CONSTRUCTION

D-7. A pump spacing triangle can be utilized to determine the location of each pump station. A properly constructed pump spacing triangle will ensure that the assault hoseline system performs within its optimal operational range. To construct a spacing triangle, obtain a piece of graph paper, transparent sheet, or cardboard thick enough to be used as a straight edge. See paragraph D-8 for a ground profile example with significant changes in elevation. Otherwise, design the pump spacing triangle as follows.

- Using the information shown below, determine the specific gravity of the fuel type that will be transported through the assault hoseline system.
  - Gasoline specific gravity: 0.7250.
  - Diesel fuel-2 specific gravity: 0.8448.
  - Jet propellant-4 specific gravity: 0.7753
  - Jet propellant-5 specific gravity: .8203.
  - Jet propellant-8 specific gravity: 0.8063.
- The 350 GPM pump has a total discharge head of 275 feet. Pumps require a suction pressure of 20 psi to operate properly. To properly design the pump spacing triangle, first determine the Net Available Head as follows:

Note: All examples use JP-8 specific gravity.

- Convert the 20 psi needed by each pump to feet of head using this formula: Feet of head = (2.31 x psi) / specific gravity. Using this formula the feet of head for this scenario is 57.3.
- To determine the net available head use this formula: Total discharge head – feet of head. Using this formula the net available head for this scenario is 218.
- Divide the vertical, left-hand edge of the pump spacing triangle, figure D-4, into spaces on the same uniform scale used to represent elevation changes on the ground profile graph. Mark off spaces along the vertical side of pump spacing triangle to the net available head:

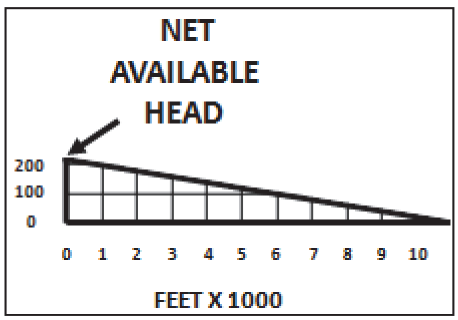

Figure D-4. Net Available Head

- To determine friction loss, or the horizontal side of the pump spacing triangle, use this formula: Net available head/Friction loss of hoseline. Friction loss is approximately 2 psi per 100 feet of assault hoseline system. Using this formula the friction loss for this scenario is 2.064 miles. To convert friction loss distance from miles to feet use this formula: Friction loss distance (in miles) X 5280. Using this formula the friction loss distance in feet for this scenario is 10,898 feet.
- Divide the horizontal base of pump spacing triangle, figure D-5, into spaces on the same uniform scale used to divide the ground profile graph base. Mark off spaces along the pump spacing triangle base to the friction loss distance.

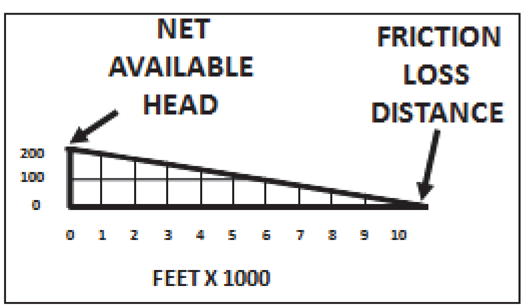

Figure D-5. Friction loss distance

- Draw a straight line, or hypotenuse, figure D-5, from the net available head mark on the vertical scale to the friction loss distance mark on the horizontal scale. This line will form the long side of the triangle, or the hydraulic gradient.
- Making sure all lines have a straight edge, cut the triangle along the three sides drawn (horizontal, vertical, and hydraulic gradient), figure D-5.

DETERMINE LOCATION OF PUMP STATIONS (PS)

D-8. Using the ground profile graph and the pump spacing triangle, refer to figure D-6 and determine pump station locations as follows:

- Place the pump spacing triangle on the ground profile graph.
- Align the vertical side of the pump spacing triangle with the vertical (elevation) side of the ground profile graph. Ensure the zero mark of the pump spacing triangle is on the lead pump station mark of the ground profile graph.
- Ensure the horizontal side of the spacing triangle is exactly parallel with horizontal base of ground profile graph. Horizontal space on both the pump spacing triangle and ground profile graph should be exactly aligned.
- Note: If the level of the ground profile is below the base of the pump spacing triangle, extend the pump spacing triangle hydraulic gradient until it crosses the ground profile.
- Mark the point at which the hydraulic gradient crosses the ground profile. This will be the second pump station location, or PS #2.
- To determine the next pump station location, PS #3, place the pump spacing triangle zero mark on the PS #2 mark of the ground profile graph. Mark the point at which the pump spacing triangle hydraulic gradient crosses the ground profile. This identifies PS #3 location.
- Remaining pump stations can be determined by using the same procedure.

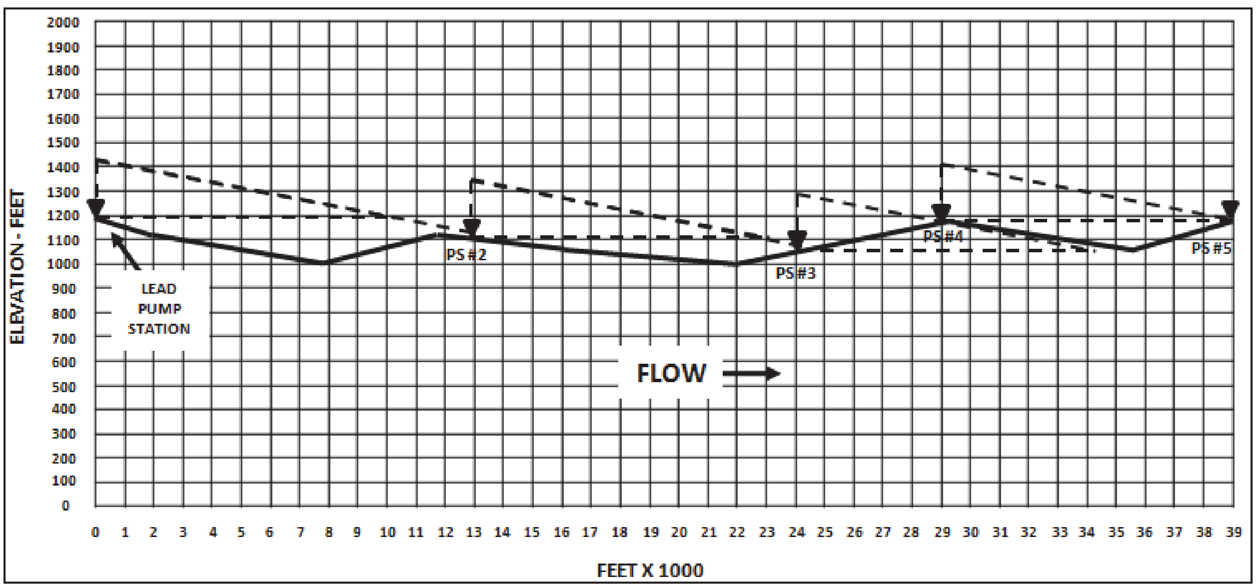

Figure D-6. Pump station locations

GROUND PROFILES WITH SIGNIFICANT ELEVATION CHANGES

D-9. To construct a pump spacing triangle for a ground profile with significant elevation changes, similar to figure D-7 on page D-6, use the same steps identified in paragraph D-6.

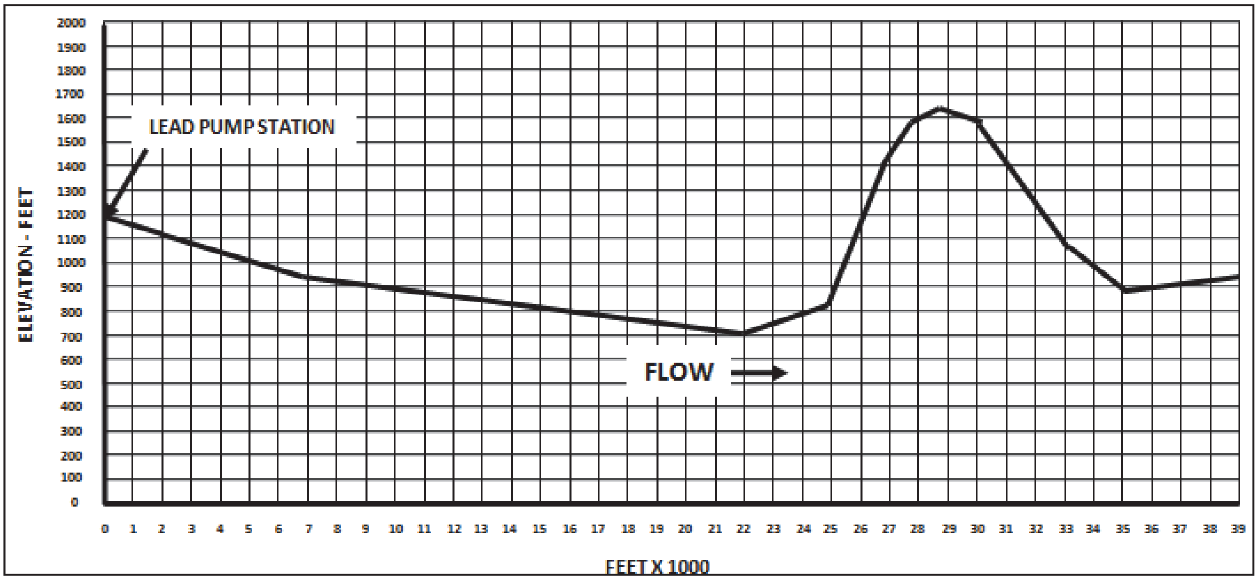

Figure D-7. Ground profile with significant elevation change

D-10. To determine pump station locations refer to figure D-8 and follow the steps in paragraph D-7.

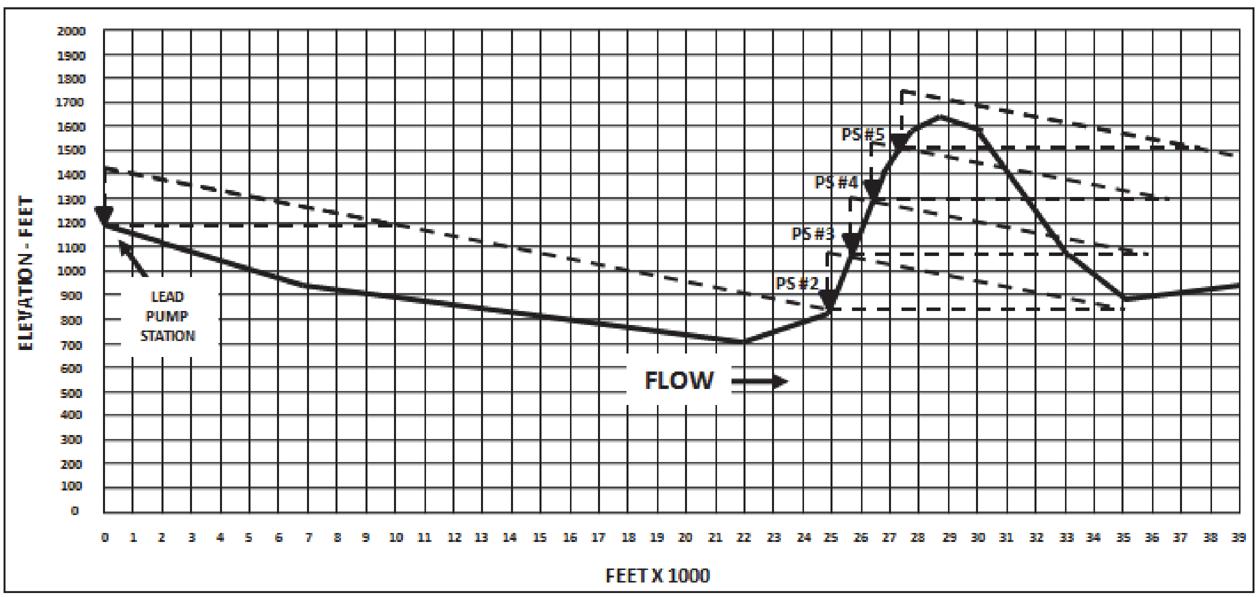

Figure D-8. Ground profile with significant elevation change pump station locations

DETERMINE LOCATION OF PRESSURE REDUCING VALVES

D-11. After locations of pumping stations have been plotted, check ground profile for any sharp declines in elevation along assault hoseline system route. An excessive drop in elevation will significantly increase hydraulic pressure.

CAUTION

To prevent damage to assault hoseline system components do not allow hydraulic pressure to exceed 150 pounds per square inch (psi).

- If pressure builds to more than 150 psi, the assault hoseline system can rupture and equipment failure may result. Therefore, when a sharp elevation drop along the assault hoseline system route is indicated by the ground profile graph, a pressure-reducing valve assembly must be installed in the assault hoseline system. To determine pressure-reducing valve assembly locations, refer to ground profile graph and proceed as follows:
- Determine the feet of head for 150 psi using the formula at the third bullet under paragraph D-6. In this scenario the feet of head is 430 feet.
- Mark crest of hill on ground profile graph, figure D-9 on page D-8.
- Draw a vertical line from the crest of hill down the that equates to the feet of head (430 for this scenario), figure D-9 on page D-8.
- Draw a horizontal line outward from the vertical line until it intersects the ground profile line. Ensure the horizontal line is parallel to horizontal base of ground profile graph, figure D-9 on page D-8.
- Where the horizontal line intersects the ground profile line is the location of the pressure-reducing valve, figure D-9 on page D-8.
- Draw a vertical line from the first pressure-reducing valve down the identified feet of head, figure D-9 on page D-8.
- Draw a horizontal line outward from the vertical line until it intersects the ground profile line. Ensure the horizontal line is parallel to horizontal base of ground profile graph, figure D-9 on page D-8.
- Where the horizontal line intersects the ground profile is the location of the next pressure-reducing valve. If the horizontal line does not intersect the ground profile, no additional pressure-reducing valves are needed, figure D-9.
- Repeat this process for all sharp declines until all pressure-reducing valve locations are identified.

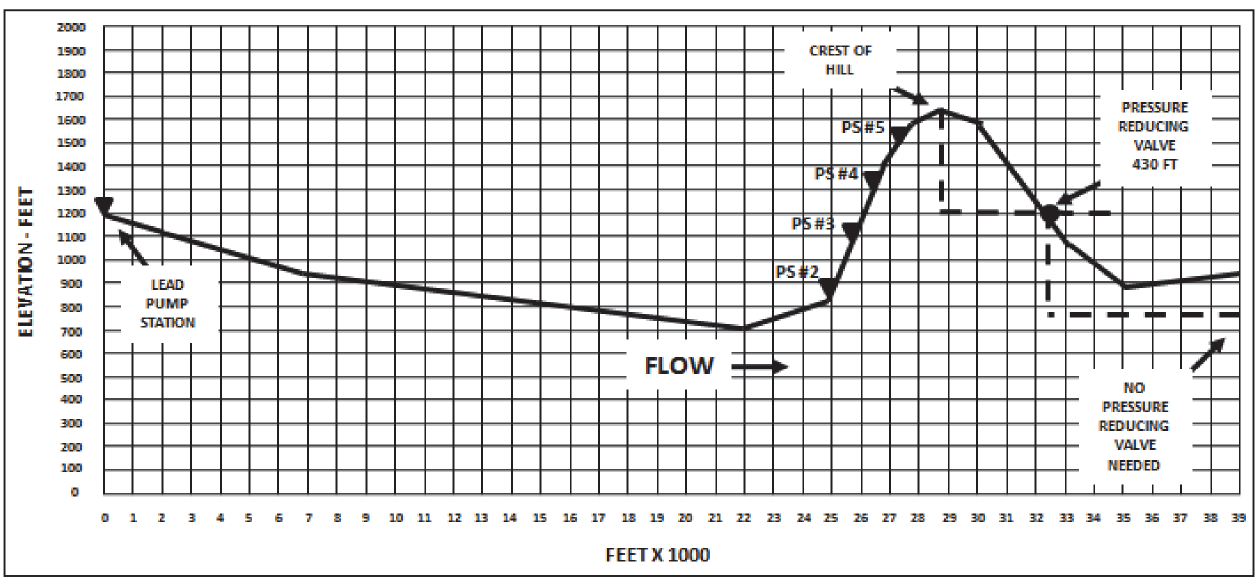

Figure D-9. Pressure-reducing valve locations

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Appendix E

Pipeline Hydraulics

In Section I, this appendix covers the petroleum product chemical and physical properties that are pertinent to pipeline/hoseline hydraulics. Both physical and chemical properties are of concern to the scheduler and dispatcher; however, only physical properties as they affect product storage and movement in pipelines are covered in this appendix. They include density, gravity, viscosity, compressibility, effect of temperature, and vapor pressure. Section II discusses the mechanics and mathematical formulas required to determine pipeline hydraulics. Section III provides a basis for determining the hydraulics of a hoseline operation.

SECTION I – PHYSICAL PROPERTIES OF PETROLEUM TYPES OF PROPERTIES

E-1. The following petroleum fuel properties provide information that is needed to plan, construct and operate a pipeline or hoseline properly.

DENSITY

E-2. All substances have weight. Their weight depends on the number and arrangement of molecules of which they are composed. Weight is a measure of the force of gravity. The weight of a definite mass of a substance varies slightly in different parts of the country because gravity varies. For this reason, weight and mass are not identical. Mass stays constant, but weight may not stay constant. The weight density or specific weight of a substance is its weight per unit volume. The term specific refers to a unit quantity. In the metric system of measurement, the mass of 1 cubic centimeter of water is 1 gram. Therefore, the density or specific weight of water is 1 gram per cubic centimeter. In the English system of measurement, the density or specific weight of water is expressed as 62.3 pounds per cubic foot. Specific volume is the space occupied by a unit quantity. In the metric system, 1 gram of water occupies 1 cubic centimeter. In the English system, 62.3 pounds of water occupies 1 cubic foot.

GRAVITY

E-3. Gravity is the attraction between matter and the earth's center. It is properly referred to as acceleration due to gravity, which is the change in speed of a body falling freely toward the earth. This change in speed is 32.2 feet per second. This means that during each second of fall, the speed increases 32.2 feet per second. Gravity is measured by weight. Petroleum operations are concerned with specific gravity and American Petroleum Institute gravity. Specific gravity and American Petroleum Institute gravity and formulas for converting one to the other are described below.

- Specific Gravity. Specific gravity is a means of comparing weights of substances. This is independent of the actual numerical value of the pull of gravity in any locality. Specific gravity is the ratio between the weight of a quantity or volume of a substance and the weight of an equal quantity of water. It is a relative measure of weight density compared with water. Solids and liquids are usually compared with water at its maximum density at 39.2°F /4°C). The specific gravity of water is 1. A substance of specific gravity 0.5 weighs half as much as water. A substance of specific gravity 5.0 weighs five times as much as water. Petroleum products moved by pipeline are lighter than water. Therefore, their specific gravities are fractions in a narrow numerical range. Specific gravity is measured with a hydrometer.
- American Petroleum Institute Gravity. The petroleum industry uses the American Petroleum Institute gravity scale almost exclusively to designate gravities of products. American Petroleum Institute gravities are based on reciprocals of specific gravities. They are whole numbers with a

greater numerical spread. The American Petroleum Institute scale has a range of 0° to 100°. Water has a gravity of 10°. This leaves a spread of 90° between the heaviest and lightest petroleum products. American Petroleum Institute gravity is inversely proportionate to specific gravity. In other words, the higher the specific gravity, the heavier the product and the lower the American Petroleum Institute gravity. The lightest products have the highest American Petroleum Institute gravities.

FORMULAS AND CONVERSION TABLE

E-4. Formulas for converting specific gravity to American Petroleum Institute gravity and vice versa are given below. For the formulas to work properly the value that you have (American Petroleum Institute or Specific Gravity) must be corrected to 60°F (15.6°C) before you use the data. Table E-1 lists American Petroleum Institute gravity and corresponding specific gravity and weights at 60°F (15.6°C).

Degrees American Petroleum Institute gravity = [141.5/Specific Gravity (corrected to 60°F)] -131.5
Specific Gravity = 141.5/[131.5 + American Petroleum Institute Gravity (corrected to 60°F)]

Table E-1. American Petroleum Institute gravity equivalents at 60°F (15.6°C)

American Petroleum Institute GRAVITY	***SPECIFIC GRAVITY***	***POUNDS PER***			***BARRELS PER***		
		US GALLON	***IMPERIAL GALLON***	***BARREL***	***LONG TON***	***METRIC TON***	***SHORT TON***
1	1.0679	8.895	10.683	373.59	5.996	5.901	5.353
2	1.0599	8.828	10.602	370.78	6.041	5.946	5.394
3	1.0520	8/762	10.523	368.00	6.087	5.991	5.435
4	1.0443	8.697	10.446	365.32	6.132	6.035	5.475
5	1.0368	8.634	10.369	362.63	6.177	6.080	5.516
6	1.0291	8.571	10.294	359.98	6.223	6.124	5.556
7	1.0217	8.509	10.219	357.38	6.268	6.169	5.596
8	1.0143	8.448	10.146	354.82	6.313	6.213	5.637
9	1.0071	8.388	10.074	352.30	6.359	6.258	5.677
10[a]	1.0000	8.328	10.002	349.78	6.404	6.303	5.718
11	0.9930	8.270	9.932	347.34	6.449	6.347	5.799
12	0.9861	8.212	9.863	344.90	6.495	6.392	5.799
13	0.9792	8.155	9.794	342.51	6.540	6.437	5.839
14	0.9725	8.099	9.727	340.16	6.585	6.481	5.880
15	0.9659	8.044	9.661	337.85	6.630	6.525	5.920
16	0.9593	7.989	9.595	335.54	6.676	6.570	5.961
17	0.9529	7.935	9.530	333.27	6.721	6.615	6.001
18	0.9465	7.882	9.466	331.04	6.766	6.660	6.042
19	0.9402	7.830	9.404	328.86	6.812	6.704	6.082
20	0.9340	7.778	9.341	326.68	6.857	6.749	6.122
21	0.9279	7.727	9.280	324.53	6.902	6.793	6.163
22	0.9218	7.676	9.219	322.39	6.948	6.838	6.204
23	0.9159	7.627	9.160	320.33	6.993	6.882	6.244
24	0.9100	7.578	9.101	318.28	7.038	6.927	6.284
25	0.9042	7.529	9.042	316.22	7.084	6.972	6.325
26	0.8984	7.481	8.985	314.20	7.129	7.017	6.365

Table E-1. American Petroleum Institute gravity equivalents at 60°F (15.6°C)

American Petroleum Institute GRAVITY	SPECIFIC GRAVITY	POUNDS PER			BARRELS PER		
		US GALLON	IMPERIAL GALLON	BARREL	LONG TON	METRIC TON	SHORT TON
27	0.8927	7.434	8.928	312.23	7.174	7.061	6.406
28	0.8871	7.387	8.872	310.25	7.220	7.106	6.446
29	0.8816	7.341	8.817	308.32	7.265	7.150	6.487
30	0.8762	7.296	8.762	306.43	7.310	7.194	6.527
31	0.8708	7.251	8.708	304.54	7.356	7.239	6.568
32	0.8654	7.206	8.654	302.65	7.401	7.284	6.603
33	0.8602	7.162	8.603	300.85	7.446	7.328	6.648
34	0.8550	7.119	8.550	299.00	7.492	7.373	6.689
35	0.8499	7.076	8.498	297.19	7.537	7.418	6.730
36	0.8448	7.034	8.448	295.43	7.582	7.462	6.770
37	0.8398	6.992	8.399	293.71	7.628	7.506	6.810
38	0.8348	6.951	8.348	291.94	7.673	7.552	6.851
39	0.8299	6.910	8.299	290.22	7.718	7.597	6.891
40	0.8251	6.870	8.251	288.54	7.764	7.641	6.931
41	0.8203	6.830	8.203	286.86	7.809	7.686	6.972
42	0.8156	6.790	8.155	285.18	7.854	7.731	7.013
43	0.8109	6.751	8.109	283.58	7.900	7.774	7.053
44	0.8063	6.713	8.062	281.95	7.945	7.819	7.093
45	0.0817	6.675	8.017	280.35	7.990	7.864	7.134
46	0.7972	6.637	7.971	278.75	8.036	7.909	7.175
47	0.7927	6.600	7.927	277.20	8.081	7.953	7.215
48	0.7883	6.563	7.882	275.65	8.126	7.998	7.256
49	0.7839	6.527	7.838	274.09	8.172	8.043	7.297
50	0.7796	6.491	7.794	272.58	8.217	8.088	7.337
51	0.7753	6.455	7.752	271.11	8.262	8.132	7.377
52	0.7711	6.420	7.710	269.64	8.308	8.176	7.417
53	0.7669	6.385	7.668	268.17	8.353	8.221	7.458
54	0.7628	6.350	7.626	266.70	8.398	8.266	7.499
55	0.7587	6.316	7.586	265.27	8.444	8.130	7.539
56	0.7547	6.283	7.546	263.89	8.489	8.354	7.579
57	0.7507	6.249	7.505	262.46	8.534	8.400	7.620
58	0.7467	6.216	7.465	261.07	8.850	8.444	7.661
59	0.7428	6.183	7.427	259.73	8.625	8.488	7.700
60	0.7389	6.151	7.387	258.34	7.670	8.534	7.742
61	0.7351	6.119	7.349	257.00	8.716	8.578	7.782
62	0.7313	6.087	7.310	255.65	8.761	8.623	7.823
63	0.7275	6.056	7.273	254.35	8.807	8.668	7.863
64	0.7238	6.025	7.236	253.05	8.852	8.712	7.904

Table E-1. American Petroleum Institute gravity equivalents at 60°F (15.6°C)

American Petroleum Institute GRAVITY	*SPECIFIC GRAVITY*	*POUNDS PER*			*BARRELS PER*		
		US GALLON	*IMPERIAL GALLON*	*BARREL*	*LONG TON*	*METRIC TON*	*SHORT TON*
65	0.7201	5.994	7.199	251.75	8.897	8.757	7.944
66	0.7165	5.964	7.163	250.49	8.943	8.801	7.984
67	0.7128	5.934	7.127	249.23	8.988	8.846	8.025
68	0.7093	5.904	7.091	247.97	9.033	8.891	8.065
69	0.7057	5.875	7.055	246.71	9.079	8.936	8.107
70	0.7022	5.845	7.020	245.49	9.125	8.980	8.147
71	0.6988	5.816	6.986	244.31	9.169	9.024	8.187
72	0.6953	5.788	6.951	243.10	9.215	9.069	8.227
73	0.6919	5.759	6.917	241.88	9.260	9.114	8.269
74	0.6886	5.731	6.883	240.70	9.305	9.159	8.309
75	0.6852	5.704	6.849	239.53	9.351	9.204	8.350
76	0.6819	5.676	6.817	238.39	9.396	9.248	8.390
77	0.6787	5.649	6.784	237.26	9.442	9.292	8.430
78	0.6754	5.622	6.752	236.12	9.487	9.337	8.470
79	0.6722	5.595	6.720	234.99	9.532	9.382	8.511
80	0.6690	5.569	6.687	238.86	9.578	9.427	8.552
81	0.6659	5.542	6.656	232.76	9.623	9.472	8.593
82	0.6628	5.516	6.624	231.67	9.668	9.516	8.633
83	0.6597	5.490	6.595	230.62	9.714	9.559	8.672
84	0.6566	5.465	6.563	229.53	9.759	9.605	8.713
85	0.6536	5.440	6.533	228.48	9.805	9.649	8.754
86	0.6506	5.415	6.503	227.43	9.850	9.694	8.794
87	0.7476	5.390	6.473	226.38	9.895	9.738	8.835
88	0.6446	5.365	6.443	225.33	9.941	9.784	8.876
89	0.6417	5.341	6.415	224.32	9.986	9.828	8.916
90	0.6388	5.317	6.385	223.27	10.031	9.874	8.957
91	0.6360	5.293	6.357	222.31	10.077	9.917	8.996
92	0.6331	5.269	6.328	221.30	10.122	9.962	9.038
93	0.6303	5.245	6.300	220.33	10.168	10.006	9.077
94	0.6275	5.222	6.273	219.37	10.213	10.050	9.117
[a] Water (H_2O) AT 60							

VISCOSITY

E-5. Viscosity is the internal resistance of a liquid to flow. A liquid is said to be viscous if it is sluggish or thick. Lubricating oil must be viscous enough to maintain a lubricating film under all operating conditions. However, it must not be so viscous that it becomes a drag or causes a power loss. Absolute viscosity is a measure of the force required to produce motion. The unit of force in the metric system is called the poise. One poise is equal to 100 centipoises. Viscosity is measured by noting the time in seconds for a standard amount of product to flow through a viscosimeter. The Saybolt Universal instrument is the type of viscosimeter commonly used for such measurements. A more accurate instrument for measuring viscosity is the Ubbelohde viscosimeter. Conversions from kinematic to Saybolt viscosity can be taken from the American Society forTesting and Materials table. (See table E-2.)

Table E-2. Kinematic viscosity converted to Saybolt Universal viscosity

KINEMATAIC VISCOSITY cSt	*EQUIVALENT SAYBOLT UNIVERSAL VISCOSITY, SECONDS*		*KINEMATAIC VISCOSITY cSt*	*EQUIVALENT SAYBOLT UNIVERSAL VISCOSITY, SECONDS*	
	AT 100°F BASIC VALUES	*AT 210°F*		*AT 100°F BASIC VALUES*	*AT 210°F*
2	32.6	32.9	27	128.1	129.0
2.5	34.4	34.7	28	132.5	133.4
3	36.0	36.3	29	136.9	137.9
3.5	37.6	37.9	30	141.3	142.3
4	39.1	39.4	31	145.7	146.8
4.5	40.8	41.0	32	150.2	151.2
5	42.4	42.7	33	154.7	155.8
6	45.6	45.9	34	159.2	160.3
7	48.8	49.1	35	163.7	164.9
8	52.1	52.5	36	168.2	169.4
9	55.5	55.9	37	172.7	173.9
10	58.9	59.3	38	177.3	178.5
11	62.4	62.9	39	181.8	183.0
12	66.0	66.5	40	186.3	187.6
13	69.8	70.3	41	190.8	192.1
14	73.6	74.1	42	195.3	196.7
15	77.4	77.9	43	199.8	201.2
16	81.3	81.9	44	204.4	205.9
17	85.3	85.9	45	209.1	210.5
18	89.4	90.1	46	213.7	215.2
19	93.6	94.2	47	218.3	219.8
20	97.8	98.5	48	222.9	224.5
21	102.0	102.8	49	227.5	229.1
22	106.4	107.1	50	232.1	233.8
23	110.7	111.4	55	255.2	257.0
24	115.0	115.8	60	278.3	280.2
25	119.3	120.1	65	301.4	303.5
26	123.7	124.5	70	324.4	326.7
			Over 70	Saybolt seconds = centistokes X 4.635	Saybolt seconds = centistokes X 4.667
Note: To obtain the Saybolt Universal viscosity equivalent to a kinematic viscosity determined at °F, multiply the equivalent Saybolt Universal viscosity at 100°F by 1+(t - 100) 0.000034: For example, 10cSt at 210°F is equivalent to 58.9 X 1.0070 or 59.3 seconds Saybolt Universal at 210°F.					

COMPRESSIBILITY

E-6. All fluids are compressible to an extent. That is, they can be made to occupy less space by increasing the pressure or decreasing the temperature. Liquids have perfect elasticity. They return to their original volume when the pressure is lowered or the temperature is increased. Products of the highest American Petroleum Institute gravity have the greatest compressibility. They can generate the highest surge pressure, known as hydraulic shock or water hammer. Products of high American Petroleum Institute gravity can also be transferred at the highest rate of flow. This also increases the possibility of surge pressure. Surge pressure must be avoided. Apart from surge pressure, compressibility has little significance in military dispatching of petroleum products.

TEMPERATURE

E-7. The effects of product temperature and its measurement and correction are described below.

E-8. Effects. Product temperature affects all of the properties discussed above. Volume, American Petroleum Institute gravity, compressibility, and volatility increase with temperature. Density, specific gravity, and viscosity decrease when the temperature increases. Pipeline throughput is higher in summer than in winter and requires less power. A pipeline heated by the sun delivers a greater volume. The American Petroleum Institute gravity is also higher in a pipeline than in the cool interior of a storage tank. Lubricating oil may be too thick to lubricate an engine properly when the engine is started on a cold morning. The same engine oil may thin out under operating temperatures. The change in viscosity with temperature is called viscosity index. It varies from product to product.

E-9. Measurements. Product is measured and tested many times between manufacture and consumption. Input stations report to the dispatcher temperatures and quantities pumped every hour. Takeoff stations report temperatures and quantities received every hour. Quantities are determined by gauging and because of the effects of temperature on volume and gravity, all measurements are corrected to 60°F (15.6°C).

E-10. Corrections. Volume correction to 60°F (15.6°C) requires observation of both gravity and temperature. They should be taken as close to the same time as possible. Combination hydrometers and thermometers make this easier. If specific gravity is taken, it must be converted to American Petroleum Institute gravity. Gravity at the observed temperature is corrected to 60°F (15.6°C). Volume correction factors are based on true or corrected gravity. Corrections are made according to the American Society for Testing and Materials/American Petroleum Institute/Institute of Petroleum measurement table 5B and 6B, volume correction. Table 5B gives factors for correcting observed American Petroleum Institute gravity to true gravity at 60°F (15.6°C). Table 6B gives correction factors for each degree or half degree of American Petroleum Institute gravity and each degree or half degree of temperature. Gravity must be corrected to 60°F (15.6°C) to ensure that the multiplier is selected from the proper group. This is most important near the ends of the eight gravity ranges. The multiplier is a ratio volume at 60°F (15.6°C) to volume at the observed temperature. If the observed temperature is higher than 60°F (15.6°C), the multiplier is less than one and the corrected volume will be smaller. If observed temperature is less than 60°F (15.6°C), the multiplier is less than one and the corrected volume will be larger.

SECTION II – FLOW IN PIPELINES HYDRAULICS

E-11. The principles of hydraulics govern flow in pipelines. Hydraulics is the branch of science that deals with the behavior of liquids. It also deals with the equipment required to raise liquids to higher elevations and to transfer them from place to place. The broad subject includes the pressure and the equilibrium of liquids at rest (hydrokinetics), as in an operating pipeline, and forces exerted on liquids by objects in motion (hydrodynamics), as in pumping equipment.

PRESSURE

E-12. Pressure is the main element in pipeline hydraulics. All forces producing pipeline flow and those opposing it can be measured in terms of pressure or head. Coupled military pipelines are low-pressure systems that operate at pressures of not more than 600 psi. The low pressure requires closer pump station spacing than in commercial pipeline. Pump stations are spaced about 12 to 16 miles apart in military systems on level terrain. Welded lines constructed for the military operate at higher pressures. The two types of pressure in a pipeline are static and dynamic.

STATIC PRESSURE

E-13. Static pressure is a measure of pressure in liquids at rest. At any level in any size or shape of container, static pressure depends solely upon the vertical height of liquid above that level. Unit pressure at the bottom of all containers is the same, 1 psi. A column of water one inch square and about 27 inches high weighs one pound. The force of one pound acts on an area of one square inch in the first container. A second container would hold 4 pounds of water distributed over 4 square inches. The third container would hold 16 pounds distributed over 16 square inches. A fourth would hold 64 pounds distributed over 64 square inches. Total pressure varies at the bottom of all containers, but unit pressure is the same, 1 psi. The height of water in all the containers, 27 inches or 2.31 feet, is the head required to produce a pressure of 1 psi. Static pressure in any column of water is the head in feet divided by 2.31 or multiplied by 0.433. Static pressure is proportionally less in a petroleum product because of its lower specific gravity. The formulas for converting head to pressure and vice versa are as follows:

$$\text{Pressure (psi)} = [\text{head (in feet)} \times \text{specific gravity}] / 2.31$$

or

$$\text{Pressure (psi)} = 0.433 \times \text{head (in feet)} \times \text{specific gravity}$$

or

$$\text{Head (in feet)} = \text{psi} / 0.433 \times \text{specific gravity}$$

DYNAMIC PRESSURE

E-14. Dynamic pressure or head is a measure of pressure in liquids in motion. Dynamic head is also a measure of potential energy or energy of position. Figure E-1 on page E-8, shows the relationship between static head and dynamic head. Static head at ground level behind the nozzle is measured by the vertical height of liquid in the tank above the ground. When liquid starts to flow down the pipe, it loses static head, but it gains in dynamic head. Potential energy becomes kinetic energy or energy in motion. Dynamic head or velocity is greatest at ground level where the stream changes direction and starts to rise. Dynamic head decreases after that until all velocity is lost. Meanwhile, the stream regains some portion of its initial static head and final static head is the head loss because of friction and change in direction. In other words, dynamic head is the static head required to accelerate the stream to its flowing velocity. It is the elevation to which a pump can push a column of liquid.

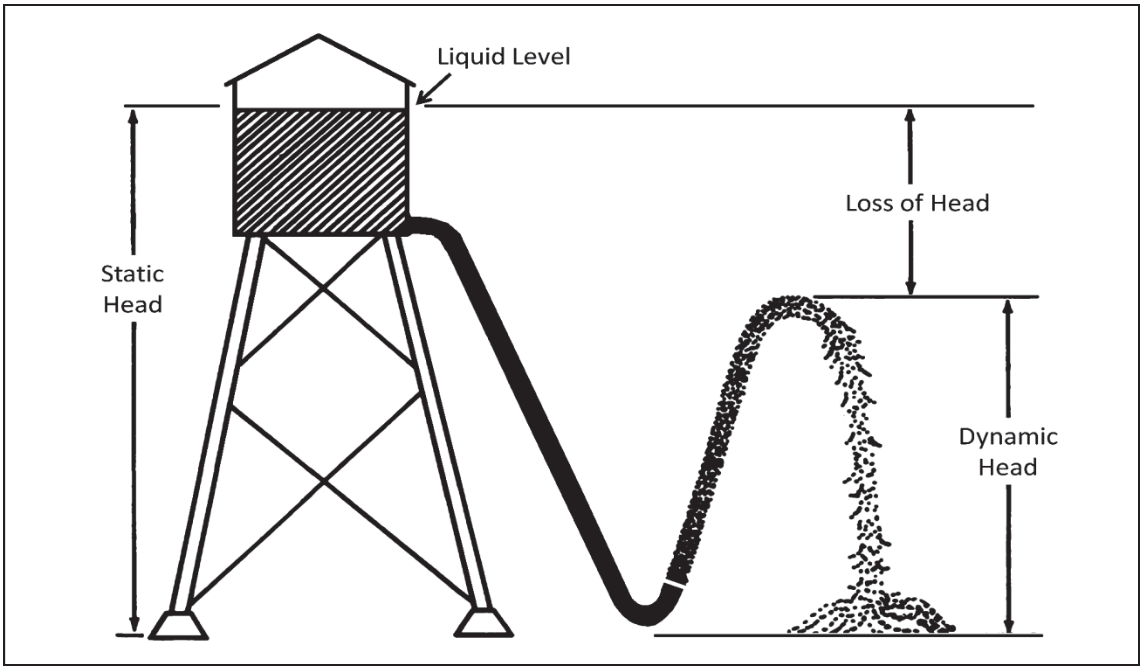


Figure E-1. Relationship between static head and dynamic head

PASCAL'S LAW

E-15. Pascal's law states that pressure, applied to the surface of a liquid, is transmitted equally in all directions through the liquid. It adds that, at any point, pressure acts at right angles to the confining container with undiminished intensity. Figure E-2 shows Pascal's law and the effect of total pressure. Unit pressure is the same on both pistons, 10 psi. This pressure is transmitted throughout the liquid. Therefore, a total pressure of 30 pounds on one piston can exert a total pressure of 1,000 pounds on the other. This principle is used in hydraulic presses, jacks, and brakes.

ATMOSPHERIC PRESSURE

E-16. Atmospheric pressure is caused by the weight of air above the earth. It is the same everywhere at any given elevation. Atmospheric pressure is similar to static pressure in liquids. The height of a column of air depends upon the height of the column. It is measured by the height in inches it raises a column of mercury in a barometer. Atmospheric pressure is 14.695 psi at sea level and proportionally less at higher altitudes. Maximum suction lift of centrifugal pumps at sea level is 33(+) feet of water (14.695 psi x 2.31). Pump engines are affected at elevations greater than 3,000 feet because of thinner air. This same condition lowers atmospheric pressure. Design loads on pumps are usually reduced by 4 percent for each 1,000 feet of elevation above 3,000 feet. Normal suction pressure of 20 psi is based on a design fuel of 0.725 specific gravity. This pressure should be increased to 30 psi for elevations over 5,000 feet.

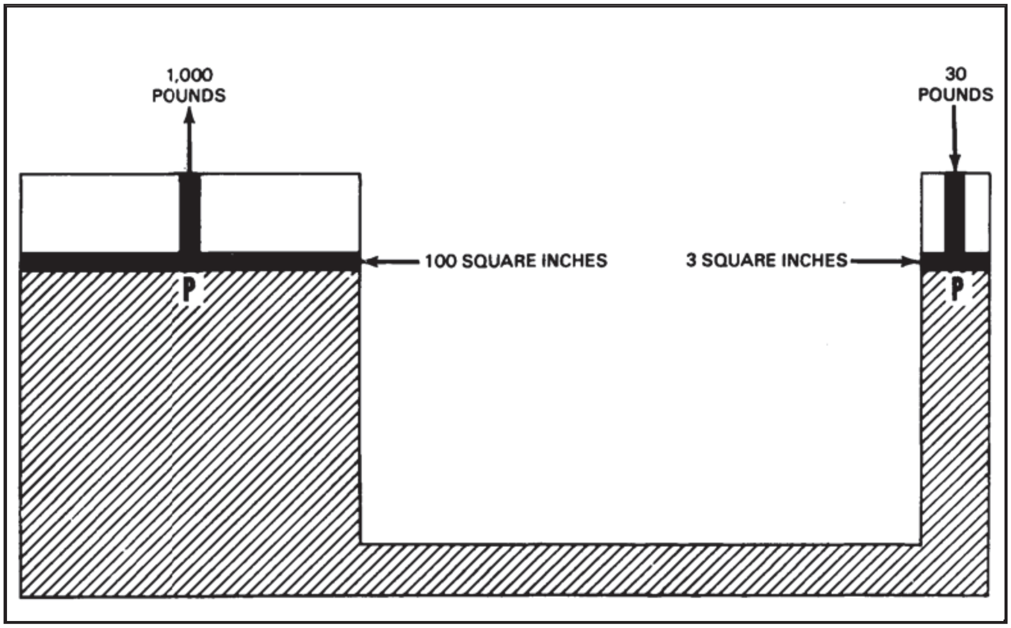


Figure E-2. Illustration of Pascal's law

VACUUM

E-17. A vacuum is created when pressure is reduced below atmospheric level. The theoretical limit of pressure reduction is absolute zero or perfect vacuum. Vacuums are measured as absolute pressure in inches of mercury. Pump suction reduces atmospheric pressure at the point of intake. This allows atmospheric pressure on the source of supply to push liquids into the pump.

VAPOR PRESSURE

E-18. All liquids, especially light petroleum products, tend to vaporize. This results from motion of the molecules of which they are composed. Motion of molecules near the surface causes some to escape into the air. The tendency to vaporize is called volatility. Volatility increases with temperature and decreases with pressure. Vapor pressure is formed when a vaporizing liquid is confined in a closed container like that used in the Reid vapor pressure test. The temperature at which a substance boils or is converted into vapor by bubbles forming in the liquid is the boiling point of the liquid. For this reason, liquids boil at lower temperatures at high elevations than at sea level. Vapor pressure reduces the effect of atmospheric pressure acting on the liquid. Maximum net suction lift is reduced accordingly. For this reason, pump suction pressure always must be greater than the vapor pressure of the product. Normal suction pressure of 20 psi should be increased to 30 psi for operating temperatures over 100°F.

NATURE OF FLOW

E-19. The three types of flow are laminar, transitional and turbulent. Liquids flow in pipelines because of gravity or pump action. In both cases, they flow because of pressure. Pressure is supplied by weight of the liquid in gravity flow and by pump action in discharge flow. While pressure and head are almost synonymous, they are actually proportional to each other.

RESISTANCE OF FLOW

E-20. Flow in a pipeline continues until the head producing it has been lost. The loss of head or the difference between pressure at the source and at any point downstream is caused by factors that resist flow. The main factors that resist flow are friction of the pipe walls and viscosity of the liquid. To calculate friction loss several factors and equations are used.

- Determine the kinematic viscosity of the fuel used in the pipeline system. Use figure E-3, page E-11 to determine kinematic viscosity using the following steps:
  - Determine the type of fuel to be used in the pipeline system and the temperature.
  - Find the temperature along the bottom axis of the figure and use a straight edge to make a vertical line that intersects the graphic line of the fuel type used.
  - At the point of intersection, turn the straight edge horizontal and make a horizontal line to the vertical axis showing kinematic viscosity on the left.
  - The point where the horizontal line intersects the vertical axis is the kinematic viscosity value in centistokes. If a reading in feet squared per second is needed use this formula: Feet squared per second = centistokes /92,900.
- Determine the Reynold's Number using this formula:
  - Design data formula. Reynold's Number = velocity in feet per second x inside diameter of the pipe in feet/kinematic viscosity in feet squared per second.
  - Field data formula: Reynold's Number = 3160 x flow rate in gallons per minute/inside diameter of the pipe in inches x kinematic viscosity in centistokes.
- Determine the friction factor using this formula: Friction factor = 64/Reynold's Number.
- Determine head loss due to friction over a given length or distance of pipe using the Darcy-Weisbach Equations:
  - Design data formula: Head loss = friction factor x length of pipe in feet x velocity squared in feet per second/64.4 x inside diameter of pipe in feet.
  - Modified formula: Head loss = 0.031 x friction factor x length of pipe in feet x flow rate squared in gallons per minute/inside diameter of the pipe in inches to the fifth power.

E-21. Figure E-4 on page E-13 provides additional information useful in determining head loss due to friction. Less important factors in flow resistance include:

- Entrance to the pipe.
- Sudden changes in cross-sectional area or direction of flow.
- Resistance of valves and fittings.
- Passage through equipment, such as meters and traps.
- Corrosion or deposits in the line.

RATE OF FLOW

E-22. The rate of flow depends on pump pressure and differences in elevation. It also depends on gravity and viscosity of the product, diameter and length of the pipe, and roughness of the pipe.

PRESSURE

E-23. There is friction between the liquid and the pipe walls. The pressure needed to overcome this resistance is expressed as head loss or loss in feet of head per mile of pipe as shown in figure E-5 on page E-14. The feet of head needed to overcome the resistance of valves and fittings is similarly expressed in equivalent lengths of pipe, table E-3 on page E-12 and figure E-5 page E-14. The total pressure needed to overcome all resistance in the line is pressure drop per mile multiplied times length of the line in miles. There is a direct relationship between pressure and rate of flow.

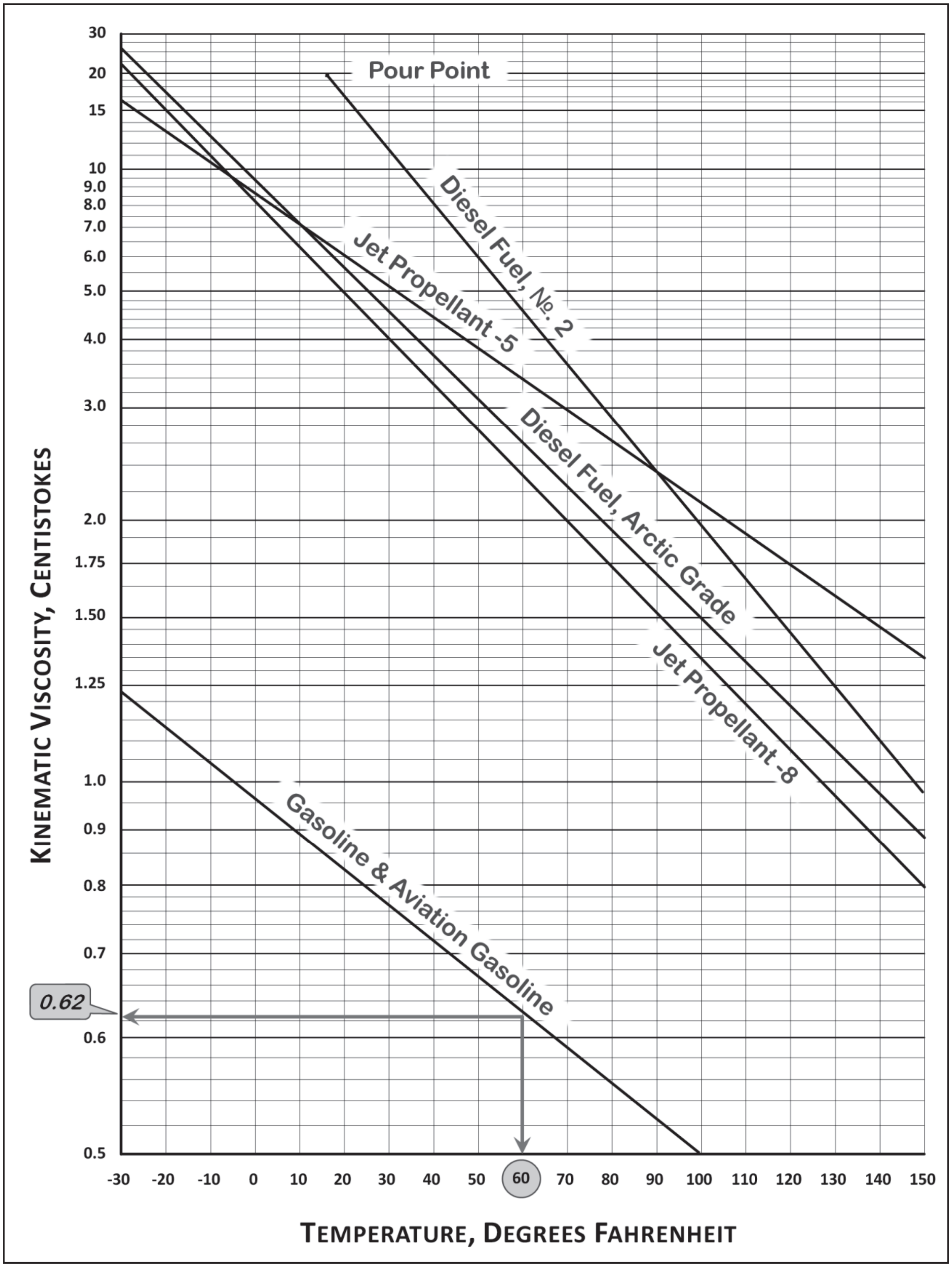
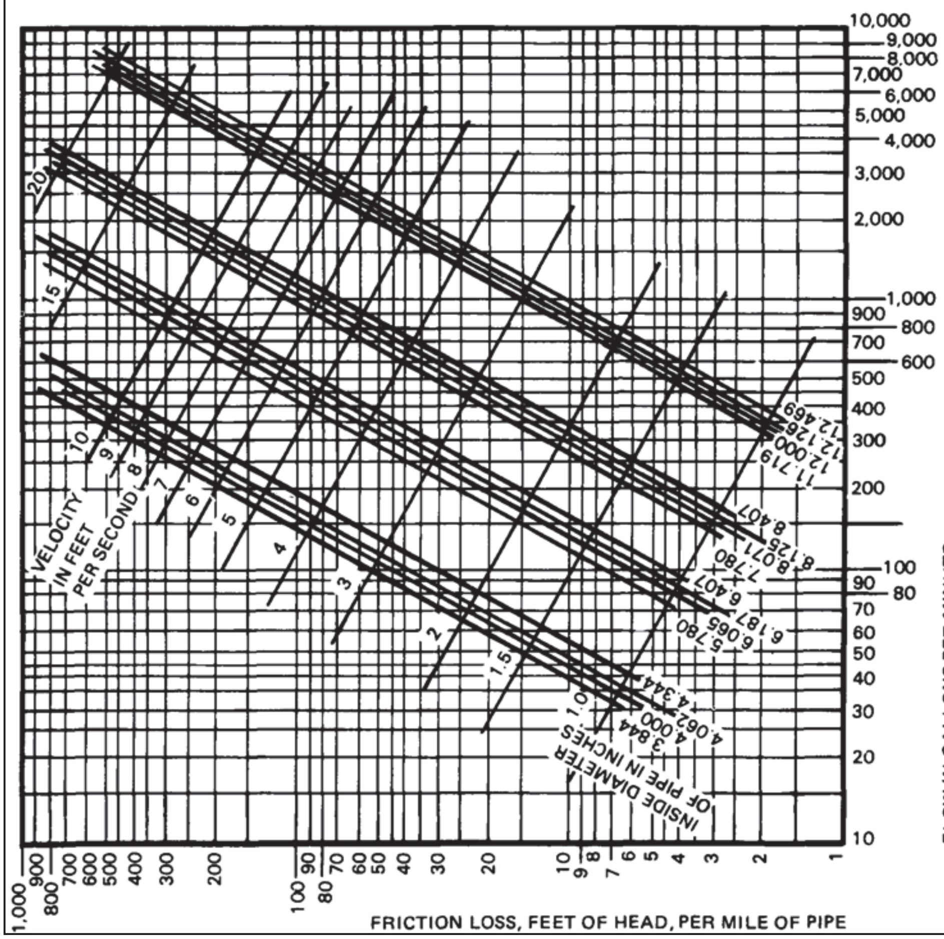


Figure E-3. Kinematic viscosities for common military fuels

Table E-3. Pipe lengths equivalent to lubricated plug valves

Nominal Size (inches)	*125-POUND CAST IRON AND 150-POUND NONFERROUS METAL*			*250-POUND CAST IRON*		*150-POUND STEEL*			*300-POUND STEEL*		
	Regular (feet)	*Short Pattern Wedge Gate (feet)*	*Venturi (feet)*	*Regular (feet)*	*Venturi (feet)*	*Regular (feet)*	*Short Pattern (feet)*	*Venturi (feet)*	*Regula r (feet)*	*Short Pattern (feet)*	*Venturi (feet)*
6	12	44	36	12	36	9.6	14.4	36		42	
8	18	54	54	18	54	12	48	54	9.6	54	54
10	24	60	60	24	60		54	60		66	60
12	30	72	78		78		72	84			77



Standard Military Pipe

Pipe OD	Pipe I D	Wall Thickness	Avg wt/ft Bare Metal	Description
Inches	Inches	Inches	Pounds	
4.000	3.844	.0781	3.46	Lt wt tubing
4.156	4.000	.0781	3.63	Lt wt tubing
4.500	4.062	.2190	10.00	Std wt API
4.500	4.344	.0781	4.10	Lt wt tubing
6.000	5.780	.1094	7.22	Lt wt tubing
6.625	6.065	.2800	18.97	Std wt API
6.625	6.187	.2190	14.97	Std wt API
6.625	6.407	.1034	8.45	Lt wt tubing
8.000	7.780	.1094	9.84	Lt wt tubing
8.625	8.071	.2770	24.70	Std wt API
8.625	8.125	.2500	22.36	Std wt API
8.625	8.407	.1094	10.55	Lt wt tubing
12.000	11.719	.1406	18.95	Lt wt tubing
12.344	12.000	.1720	23.30	Lt wt tubing
12.750	12.000	.3750	49.56	Std wt API
12.750	12.090	.3300	43.77	Std wt API
12.750	12.126	.3120	41.51	Std wt API
12.750	12.469	.1406	20.00	Lt wt tubing

Curves are based on the following:

Gasoline with specific gravity of 0.725 at 60°F.
Kinematic viscosity of 8×10^{-6} ft²/sec
Roughness constant C = 130

Fanning equation:

$$h = \frac{.03112\, f\, L\, q^2}{d^5}$$

h = Head loss due to friction, feet
f = Friction factor (dimensionless)
L = Length of pipe, feet
q = Flow of liquid, GPM
d = Inside diameter of pipe, inches

Reynolds number:

$$R = \frac{Dv}{K}$$

D = Inside diameter of pipe, feet
V = Velocity of flow, ft/sec
K = Kinematic viscosity

Ft hd = 3.19 × psi
GPM = 0.7 × BPH

Figure E-4. Pressure loss (Feet/Head) due to friction in pipe

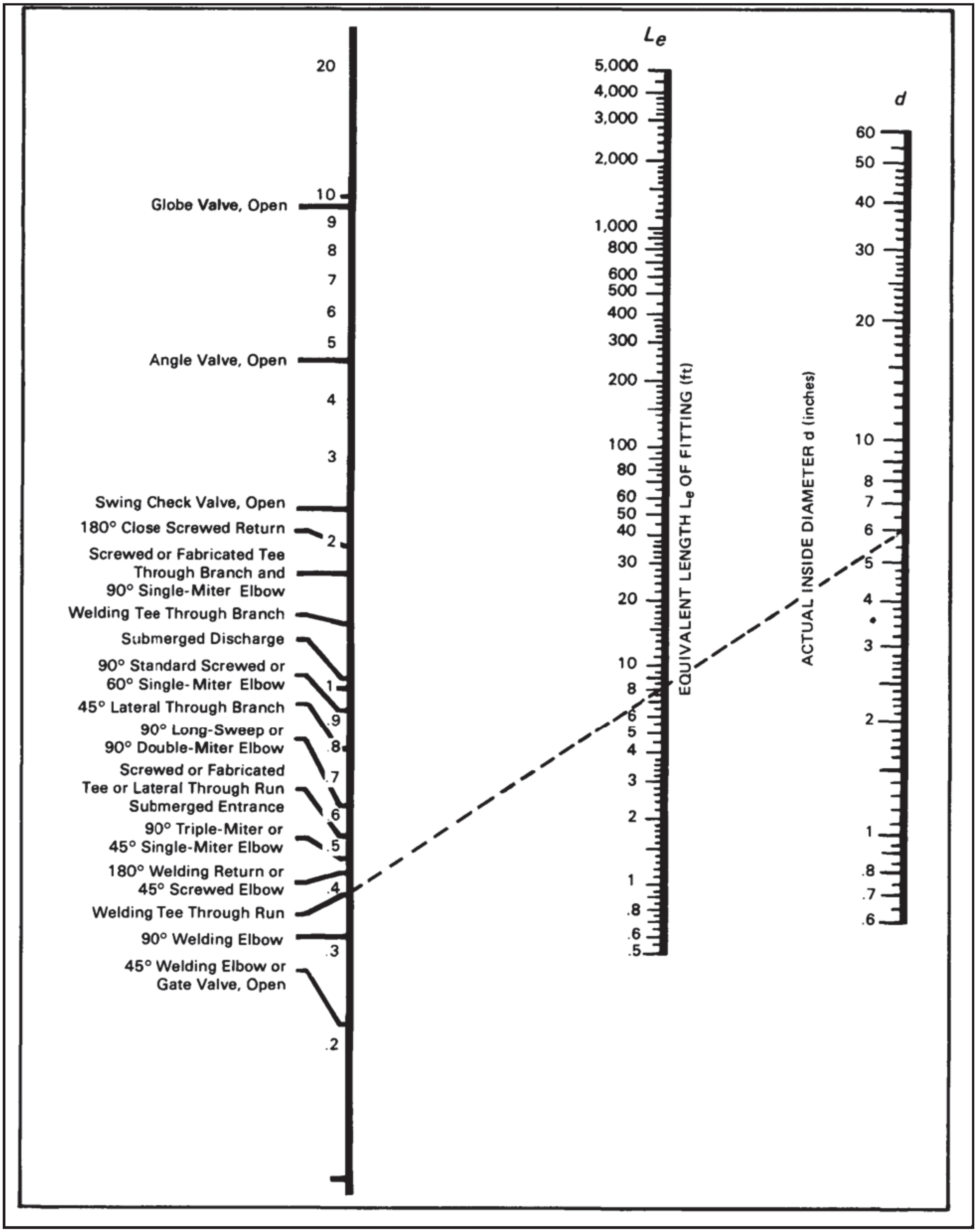


Figure E-5. Pipe lengths equivalent to valves and fittings

ELEVATION

E-24. Pressure needed to overcome friction is not the total pressure supplied if the product is to be pumped over a hill higher than the pump. The pressure equivalent of the difference in elevation in feet must be added to the pressure needed to overcome friction. If the liquid is to flow downhill from the pump, the difference in elevation can be subtracted. Otherwise, the liquid will flow proportionally farther at the same pump pressure. Elevation or static pressure acts at all times on a filled line whether the liquid is flowing or not.

GRAVITY

E-25. Specific gravity of the product is important because the liquid being moved has weight. The greater the specific gravity, or the lower the American Petroleum Institute gravity, the greater must be the pump pressure to move it. As heavier products are pumped in the line, pressure must be increased to keep the same flow rate. At the same pressure, flow rate falls off to suit the heaviest product being pumped. Observed gravity should be used in rate-of-flow computations instead of true gravity. This is because the computation will be concerned with an actual, not theoretical, condition. Changing from 40° American Petroleum Institute gravity to 60° American Petroleum Institute gravity lessens pressure requirements 10 percent. At the same pressure, changing from 40° American Petroleum Institute gravity to 60° American Petroleum Institute gravity increases rate of flow about 7 percent.

VISCOSITY

E-26. Viscosity and specific gravity of product affect pump pressure in the same way. Both gravity and viscosity vary with temperature. Therefore, locations with temperature differences of about 50°F (10°C) require 10 to 20 percent higher pumping pressures in winter.

DIAMETER OF PIPE

E-27. The pressure needed to pump at a given flow rate decreases rapidly as pipe diameter increases. It requires about 85 feet of pressure drop per mile to pump gasoline at the rate of 550 GPM through a 6.407-inch pipeline. Only about 22 feet of pressure drop are needed to pump at the same rate through 8.407-inch pipeline as shown in figure E-4, page E-13. The decrease is about 74 percent. The same rate of flow requires about 600 feet of pressure drop for 4.344-inch pipeline. This is an increase of more than 500 percent. At any given pressure, throughput may be increased about threefold by increasing the pipe diameter 50 percent.

LENGTH OF PIPE

E-28. Required pumping pressure increases directly with distance pumped. In other words, pressure drop per mile is proportional to distance pumped. If distance is doubled, pressure must be doubled. If pressure stays constant, rate of flow varies inversely as the approximate square root of length. For example, if station spacing is decreased by one half, flow rate will increase by about one half.

ROUGHNESS OF PIPE (FRICTION FACTOR)

E-29. Required pumping pressure increases directly with roughness of pipe. For this reason, scrapers and corrosion inhibitors must be used to keep the pipeline in good operating condition.

SECTION III – EXAMPLES OF FLOW HYDRAULIC GRADIENT

E-30. Figure E-6 on page E-16 shows what is meant by hydraulic gradient. The figure shows a tank with a pipeline of uniform size and grade connected at point A and discharging into the atmosphere at point B. Vertical pipes that open to the atmosphere have been connected at points X, Y, and Z. The tank is filled with product to a height of 10 feet above A and B. The hydraulic gradient exists only under conditions of flow. It is assumed that the level of product in the tank stays the same when flow begins. Product rises in each of the vertical pipes to a height (D, E and F) that represents the remaining feet of head at X, Y and Z.

The head that has been lost at each point is proportional to the length of pipe through which product has flowed. Pressure head is lost uniformly from A to B. This uniform loss of head is the hydraulic gradient. It is shown by the line connecting points C, D, E, F and B.

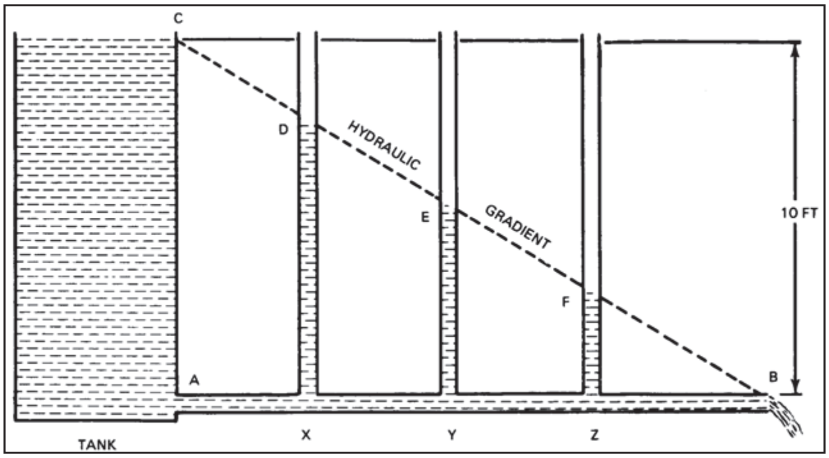


Figure E-6. Hydraulic gradient

DOWNHILL FLOW

E-31. Figure E-7 shows a situation in which the product flows downhill. Conditions are the same as in figure E-5, page E-14, except that point B is 10 feet below the tank connection A. This change increases the head to 20 feet. The new C to B line is the hydraulic gradient. This gradient is steeper than in figure E-5, page E-14. The rate of flow or velocity is also greater.

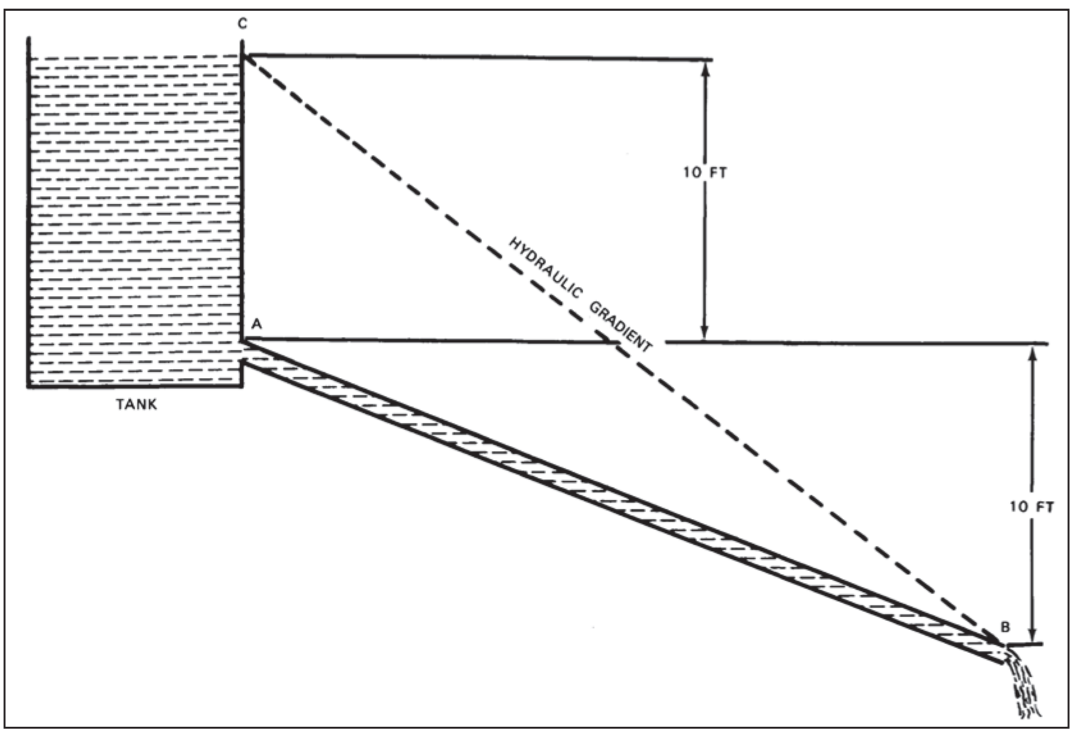


Figure E-7. Downhill flow

UPHILL FLOW

E-32. Figure E-8 shows a situation in which product flows uphill. The point of discharge B is 5 feet above the tank outlet A. Effective head has been reduced to 5 feet. The hydraulic gradient is not as steep as that in figure E-6, page E-16. The rate of flow is also less. The tank could not be emptied by gravity below point D.

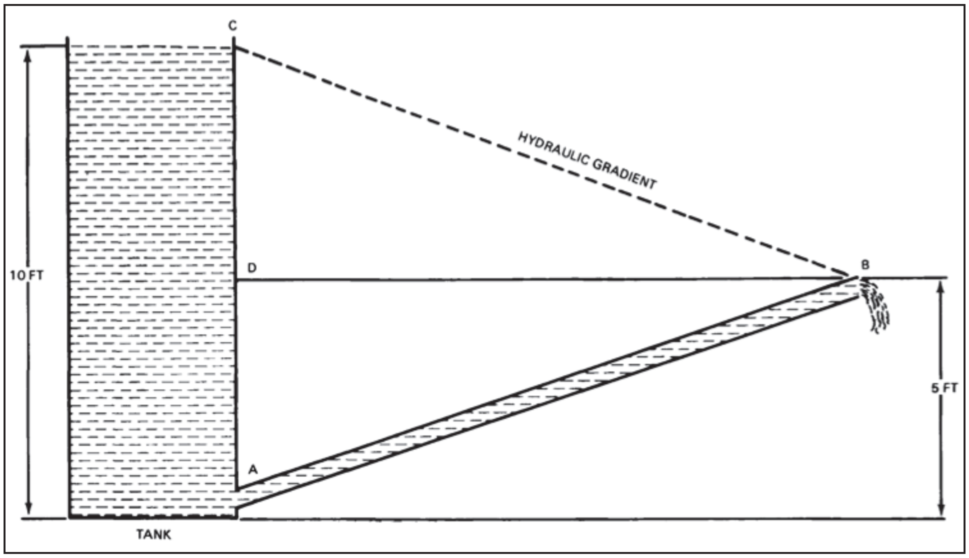


Figure E-8. Uphill flow

SIZE OF PIPE

E-33. Figure E-9 shows a situation in which size of the line is increased at point X. Pressure lost because of friction is greater in smaller pipe than in the larger pipe. Therefore, the hydraulic gradient is not a straight line from A to B. Instead, it has a steeper slope from A to X and a lesser slope from X to B.

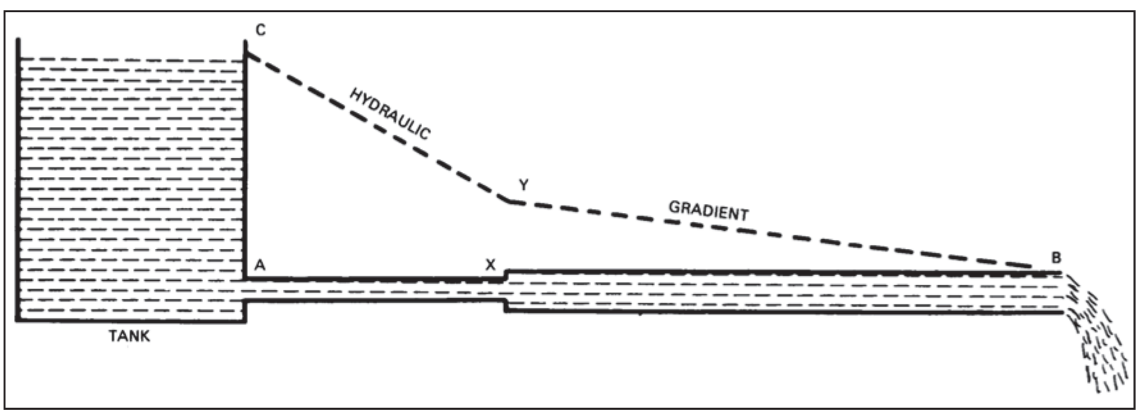


Figure E-9. Varying size of pipe

Appendix F
Tank Strapping

TERMS

F-1. There are a number of terms used in describing tank strapping procedures. Some of these terms are defined below.

- Tank height is the distance from the top of the tank shell to the inside surface of the tank floor.
- Product height is the highest fill point of the tank. This is not necessarily the top of the tank.
- Deadwood is any part of the interior of the tank that reduces or adds to the volume. Such items as ladders, supports, bolts, nuts, and channels are deadwood in the tank.

METHODS

F-2. As a rule, a strapping chart is prepared for each storage tank because tanks of the same size may vary in capacity. Storage tanks must be filled before they are strapped, because the walls expand slightly when the tanks are filled. Tank strapping methods are given below.

ALL-RINGS

F-3. The all-rings method is very accurate. Its error rate is only 1/50 of 1 percent. This method requires the following:

- Measurement of the outside circumference of each ring of the tank.
- Measurement of the height of each ring of the tank.
- Computation of the inside diameter of each ring of the tank.
- Computation of the volume of the tank.

AVERAGE CIRCUMFERENCE

F-4. The average circumference method is less accurate than the all-rings method. This method results in an average of 1/10 of 1 percent error. The average circumference method requires the following:

- Measurement of the outside circumference of all rings of the tank and the average of these measurements.
- Computation of the diameter from the circumference averages.
- Computation of the inside diameter of the tank.
- Computation of the volume of the tank.

ONE-RING

F-5. The one-ring method has an error rate of about 1/5 of 1 percent. This method requires the following:

- Measurement of the diameter of the second or third ring of the tank.
- Measurement of the total height of the tank.
- Computation of the inside diameter of the tank.
- Computation of the volume of the tank.

COMPUTATION

F-6. This paragraph gives an example of a tank strapping computation on a single-ring tank as shown in figure F-1 on page F-3. The information on tank measurements and deadwood that is needed in the strapping procedure is given in table F-1 on page F-3.

- First, find the outside diameter of the tank.

Outside diameter = circumference / π

- Then find the inside diameter of the tank.

  Inside diameter = outside diameter - 2 x wall thickness

- Now find the V of the tank, uncorrected for deadwood.

  V = [(π Inside diameter^2 x height) x 7.48 gallons per cubic foot] / 4

- Find the volume of the pipe connection and the cleanout door.

  - V pipe connection = π D H2 x 7.48 / 4
  - V cleanout door = length x height x depth x 7.48

- Now find the volume of the deadwood. The only deadwood in this tank is the roof support.

  V roof support = π D^2 H x 7.48 / 4

- Find the total volume of the tank.

  V uncorrected + V cleanout door + V pipe connection = total volume

- Now, subtract the deadwood from the total volume to get the total corrected volume of the tank.

  19,417.97 - V roof support = total corrected volume

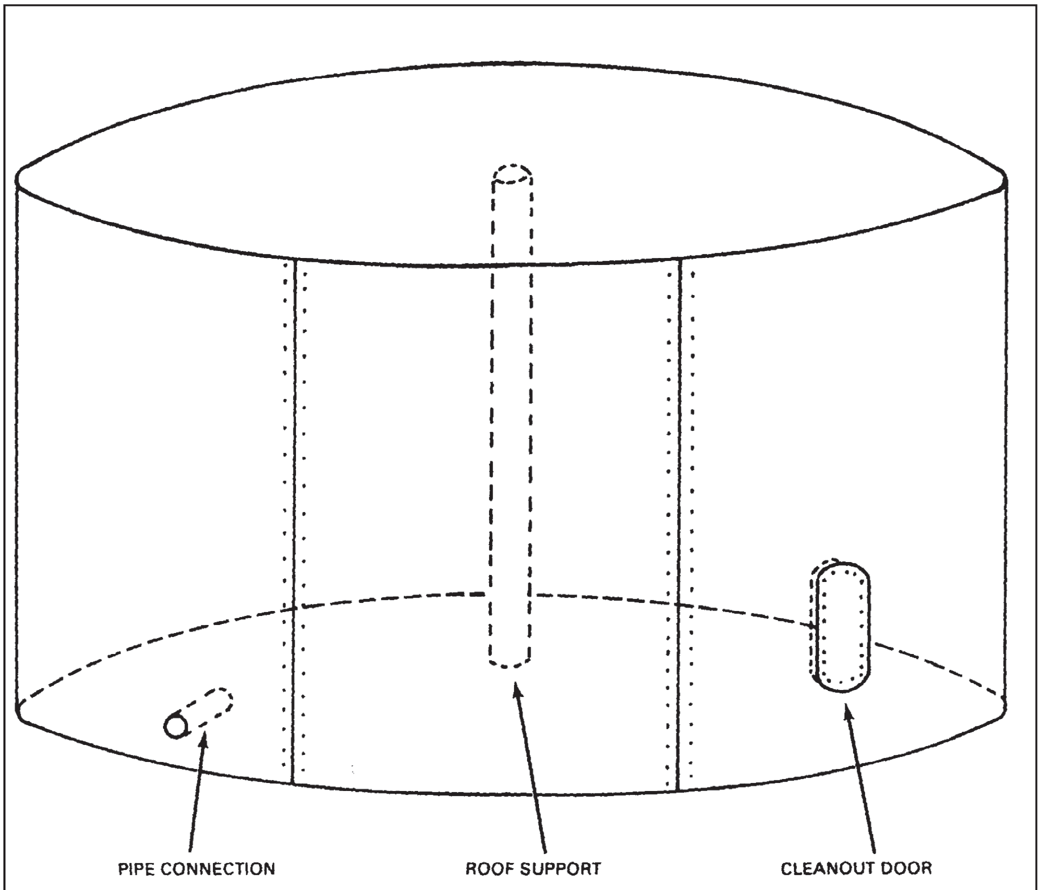


Figure F-1. Single ring tank

Table F-1. Tank measurements and deadwood

TANK	***MEASUREMENTS***
Outside circumference	40 feet 6 inches
Wall thickness	1/2 inch
Height	20 feet
Pipe connection	2 feet long, 8 inches in diameter
Cleanout door	3 feet by 5 feet by 1 foot
DEADWOOD	***MEASUREMENTS***
Roof support	6 inches in diameter
Pipe connection	2 feet long, 8 inches in diameter
Cleanout door	3 feet by 5 feet by 1 foot

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Appendix G

Volume Conversion

AMERICAN SOCIETY FOR TESTING AND MATERIALS/AMERICAN PETROLEUM INSTITUTE/INSTITUTE OF PETROLEUM TABLE 5A/B

G-1. Table 5A/B gives the values of American Petroleum Institute gravities at 60°F (15.56°C) corresponding to American Petroleum Institute gravities observed with a glass hydrometer at temperatures other than 60°F (15.56°C). In converting American Petroleum Institute gravity at the observed temperature (hydrometer indication) to the corresponding American Petroleum Institute gravity at 60°F (15.56°C), two corrections are necessary. The first correction is the change in volume of the glass hydrometer by temperature. The second correction is the change in volume of the oil. Both corrections have been applied to this table.

Note: This table must be used with American Petroleum Institute gravities (hydrometer indications) measured with a soft glass hydrometer calibrated at 60°F (15.56°C).

FUEL CLASSIFICATION BY AMERICAN PETROLEUM INSTITUTE GRAVITY PROCEDURES

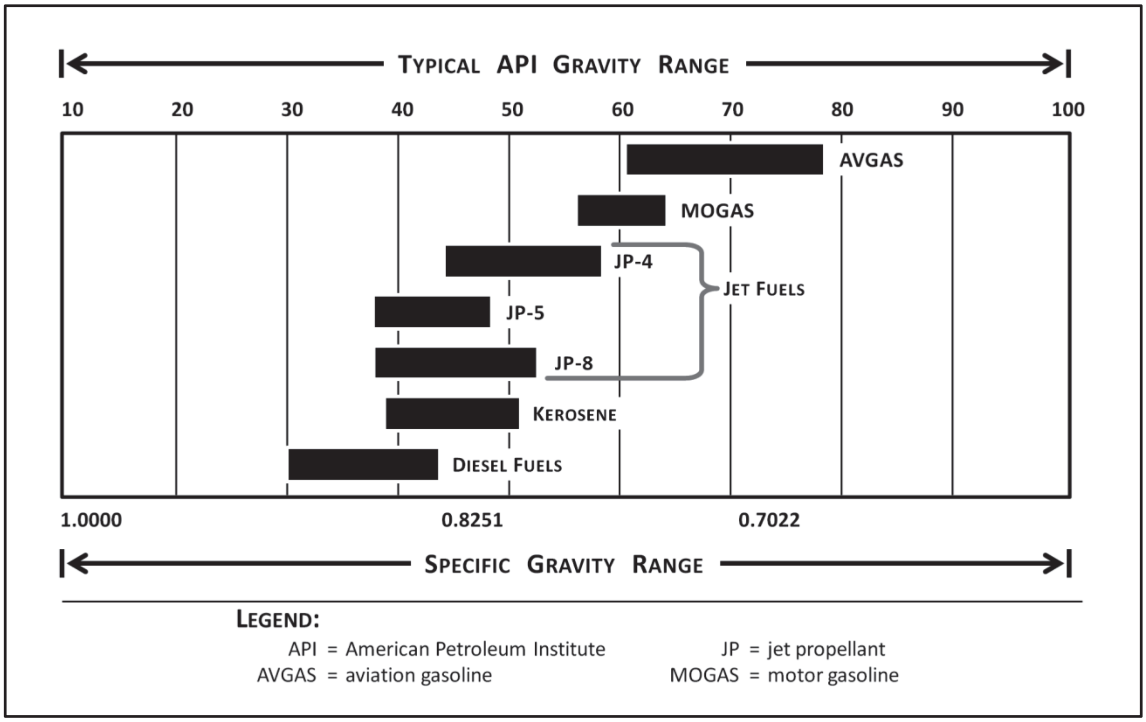
G-2. The first step in volume conversion is fuel classification.

- Taking the Readings. Described below are the procedures that must be followed during fuel classification.
  - Step 1. Draw a 300-milliliter sample of fuel from the drum, nozzle, or other fuel source. Put it into a clean dry sample bottle, quart bottle with lid, or a sample can. Cover the sample container. Take the sample to a tent, building, or other sheltered place to conduct the test. Conduct the test promptly while the sample is fresh.
  - Step 2. Agitate the contents of the sample container by shaking it thoroughly.
  - Step 3. Slowly and carefully pour the sample down the inside of a clean, dry hydrometer cylinder, filling the cylinder approximately 3/4 full.
  - Step 4. Allow any air bubbles that are deep in the liquid to rise to the surface. Hold the cylinder just below the rim with one hand, and tap the top of the cylinder sharply with the cupped palm of the other hand to remove surface air bubbles.
  - Step 5. Set the cylinder on a level surface where it is protected from air currents.
  - Step 6. Use the hydrometer with the range closest to the American Petroleum Institute gravity range of the fuel you think you are testing. (See figure G-1 on page G-2.) For example, if you think the fuel is diesel and the American Petroleum Institute gravity range of diesel is between 30.0 and 42.0, use the third or fourth hydrometer from the equipment list.
  - Step 7. Check the mercury column if the hydrometer being used has a built-in thermometer. If the mercury has separated, the hydrometer will not take acceptable temperature readings, and you should use another hydrometer. If a hydrometer with an accurate thermometer is not available, you may use a calibrated tank thermometer to measure the temperature.
  - Step 8. Lower the hydrometer gently into the sample.

Note: If the hydrometer sinks or floats with the scale out of the fuel, you have selected the wrong one for the type of fuel you are testing. Try another hydrometer close to the same range. Keep trying until a hydrometer floats in the sample.

- Step 9. Stir the sample gently by raising and lowering the hydrometer, and watch the movement of the mercury in the thermometer. (A fast-registering thermometer should give an accurate reading in 30 to 45 seconds.) When the mercury stops moving, take a temperature reading and record it.
- Step 10. Allow the hydrometer to come to rest, but not touching the side of the cylinder. If it moves to the side, move it back to the center of the liquid and spin it gently.
- Step 11. When the hydrometer is floating freely at rest, read it to the nearest scale division. Have your eye slightly below the level of the liquid, and raise it slowly until the surface of the liquid appears to be a straight line across the hydrometer scale. Record the gravity reading to the nearest scale division as shown in figure G-2.
- Step 12. Stir the sample gently again by raising and lowering the hydrometer, and take a second temperature reading. If the temperature of the fuel has not varied more than 1 °F from the previous reading, record the temperature to the nearest 1°F. This is your test temperature reading. If the temperature of the sample has changed more than 1°F, repeat steps 9 through 12 until the temperature are stable (within 1°F).

Figure G-1. Typical American Petroleum Institute gravity ranges (corrected to 60 degrees)



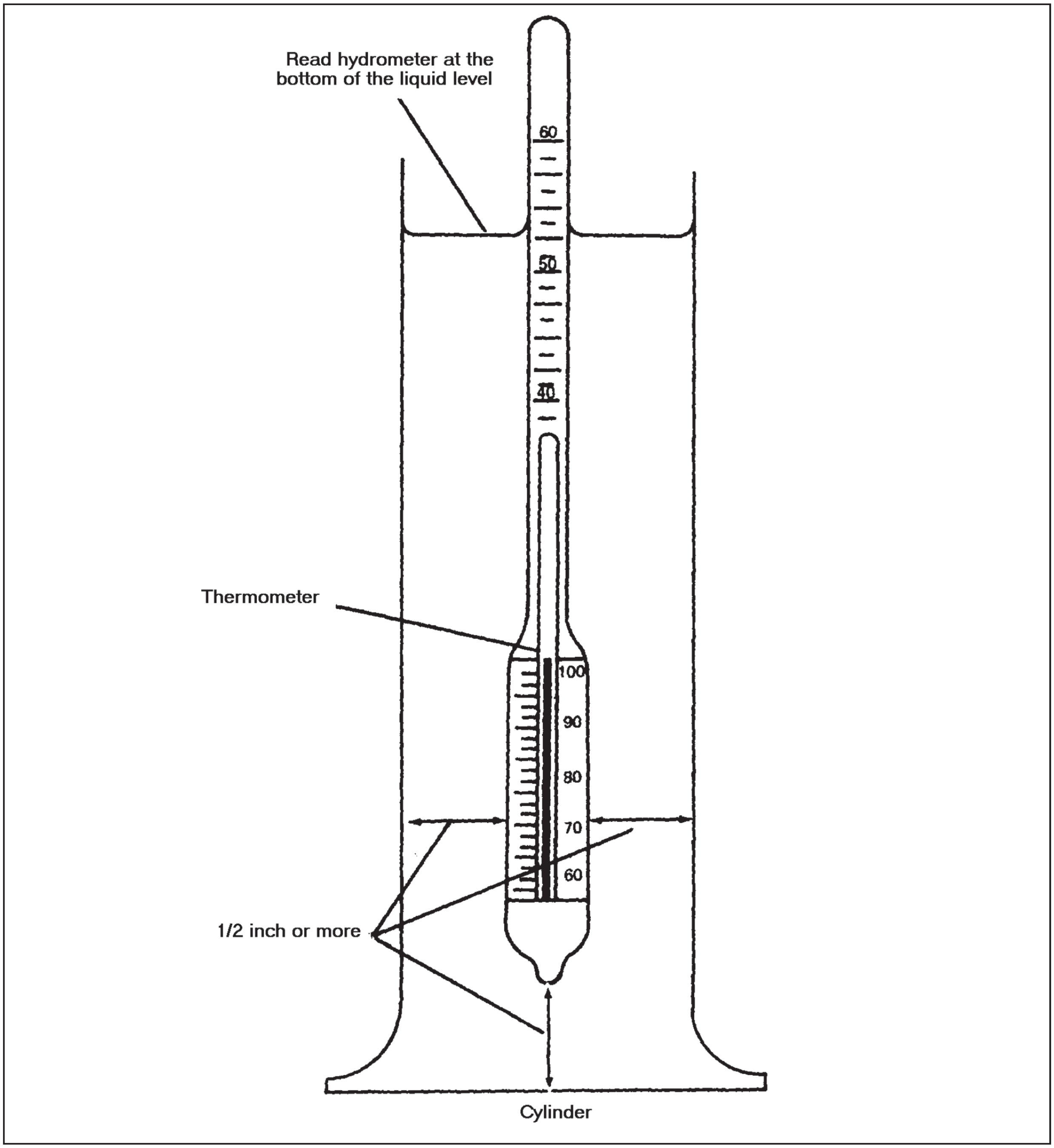


Figure G-2. Hydrometer ready to be read

CORRECTING OBSERVED READING TO 60°F (15.56°C)

G-3. Using Table 5A/B, correct the American Petroleum Institute gravity of the observed temperature to American Petroleum Institute gravity at 60°F (15.56°C). Table 5A is used for JP-4 and Table 5B is used for petroleum products other than JP-4. Example: Assume the observed hydrometer reading is 40.4 and the observed temperature is 83°F (28.3°C). The product is not JP-4. The steps are given below to correct the observed reading to 60°F (15.56°C).

- Step 1. Find the Table 5B page that lists American Petroleum Institute gravity of 40 through 45 at observed temperature across the top and the observed temperature range of 60°F (15.56°C) through 90°F (32.22°C) down the left side.
- Step 2. Read down the left side until you find the observed temperature (83.0 °F or 28.3°C). The observed American Petroleum Institute reading of 40.4 is rounded to 40.5 (The American Petroleum Institute gravity is in increments of 0.5, so the observed American Petroleum Institute gravity must be rounded to the nearest 0.5). Read across the table to where the observed American Petroleum Institute gravity of 40.5 intersects the observed temperature of 83.0°F (28.3°C). The American Petroleum Institute gravity at 60°F (15.56°C) is 38.7.

Note: For more precise American Petroleum Institute gravity correction to 60°F (15.56°C), interpolation is used. See American Society for Testing and Materials 1250. However, when American Petroleum Institute gravity is corrected to 60°F (15.56°C) for the purpose of volume correction using Table 6A/B, interpolation is not required.

- Step 3. American Petroleum Institute gravity that is recorded on the gage worksheet for volume correction use only must be rounded off to the nearest 0.5. Round off to the nearest 0.5 as follows:
  - If the fraction is 0.1 or 0.2, round down to the nearest whole degree. (For example, 42.2 become 42.0.)
  - If the fraction is 0.3, 0.4, 0.5, 0.6, or 0.7, round to the nearest 0.5 degree. (For example 38.3 becomes 38.5, or 38.7 becomes 38.5.)
  - If the fraction is 0.8 or 0.9, round up to the nearest whole number. (For example, 42.8 become 43.0.)

CLASSIFYING THE FUEL

G-4. The fuel is now classified. The steps are described below:

- Step 1. Compare the corrected American Petroleum Institute gravity with the American Petroleum Institute gravity ranges shown in Figure G-1, page G-2. If the corrected American Petroleum Institute gravity of the product is lower or higher than expected, it indicates possible commingling with either heavier or lighter products.
- Step 2. If the corrected American Petroleum Institute gravity is NOT within range for the fuel you are testing, isolate and mark the fuel container; sample the fuel; and send the sample to your supporting laboratory for identification, complete analysis, and disposition instructions. Do not use the fuel until you receive disposition instructions from the laboratory.

AMERICAN SOCIETY FOR TESTING AND MATERIALS/AMERICAN PETROLEUM INSTITUTE/INSTITUTE OF PETROLEUM TABLE 6A/B

G-5. Table 6A/B gives you the facts you need to convert product volumes observed at temperatures other than 60°F (15.56°C) for values of American Petroleum Institute gravity in the range of 0° to 100°. The volume correction factor in these tables makes no allowance for the thermal expansion of tanks and other containers. You must use these tables with American Petroleum Institute gravity values at 60°F (15.56°C) and values measured at Fahrenheit temperatures. Table 6A is used for JP-4 and table 6B is used for all petroleum products other than JP-4 See DA Pam 710-2-1. For example, what is the volume of 63,162 gallons of diesel at 83°F (28.3°C)? The product's American Petroleum Institute gravity at 60°F (15.56°C) is 38.5. Use the Table 6B column "American Petroleum Institute gravity at 60°F," headed 38.5° , and note that against an "Observed Temperature" of 83°F (28.3°C) the factor is 0.9890. Therefore, 1 U.S. gallon of product having a gravity of 38.5° at 60°F (15.56°C) and measured at 83°F (28.3°C) occupies at 60°F (15.56°C) a volume of 0.9890. Thus, 63,162 U.S. gallons measured at 83°F (28.3°C) occupy a volume of 63,162 x 0.9890 (or 62,467) U.S. gallons at 60°F (15.56°C).

Appendix H
Records and Reporting Requirements

The following explains the records that are petroleum-specific that those in fuel specialties must know how to complete with the exception of the accounting forms which are documented in DA Pam 710-2-1 & 2.

BULK STORAGE TANK RECORD

H-1. The bulk storage tank record (figure H-2 on page H-2) is used to document the initial inspection of collapsible fabric tanks when they are placed into service. Additionally the bulk storage tank record tracks deficiencies as they occur over time. A bulk storage tank record is initiated when the tank is initially inspected for service and updated as subsequent inspections identify reportable deficiencies in the tank. The bulk tank storage record is not a standard form and can be created by a DOD representative or military site supervisor using available paper stock. The information shown in figure H-2 must be on the record. Use the black, red, amber, green rating to determine deficiencies. The data on this form serves as input for the Bulk Storage Tank Spreadsheet. The following must be adhered to:

- The DOD representative or military site supervisor providing oversight of the fuel site is responsible for ensuring that the record is complete and maintained.
- A bulk storage tank record will be completed for all tanks in service.
- The bulk storage tank record will be updated as tank inspections note changes in the tank. All changes to the condition of the tank will be annotated.
- Information for the bulk storage tank record heading will be obtained from the data plate (figure H-1) located on the tank. Record all information in ink. This information may also be found stenciled on the packaging crate.
- Mark the bulk storage tank record (figure H-3 on page H-3) with the tank's orientation based on another tank or other immovable object.
- Use the legend located on the bulk storage tank record to provide a snapshot of current conditions. This is to be done in pencil.
- Seepage along large areas can be addressed with a large oval.
- Annotate berm liner deficiencies.
- Document the initial inspection and all changes to the tank's condition with the date, which is necessary for documenting deterioration and repairs over time.

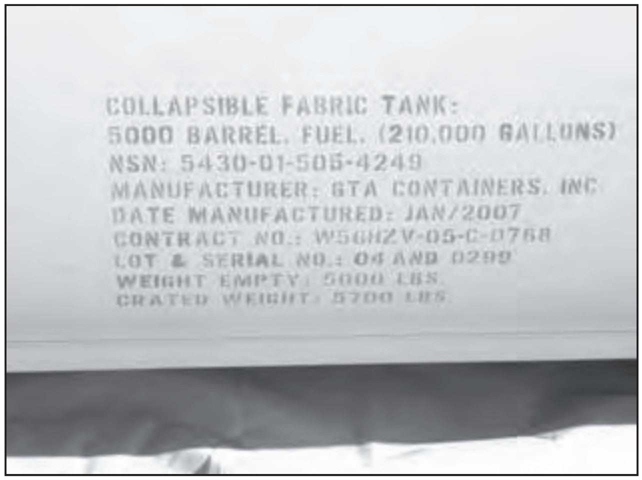


Figure H-1. Data plate on 210,000-gallon fuel tank

Bulk Storage Tank Record

Location:
Manufacturer:
Manufacture Date:
Lot &Serial No:
Date In Service:
Bag number:

Capacity:
Product:
NSN:
Contract #:
Date Out of Service:

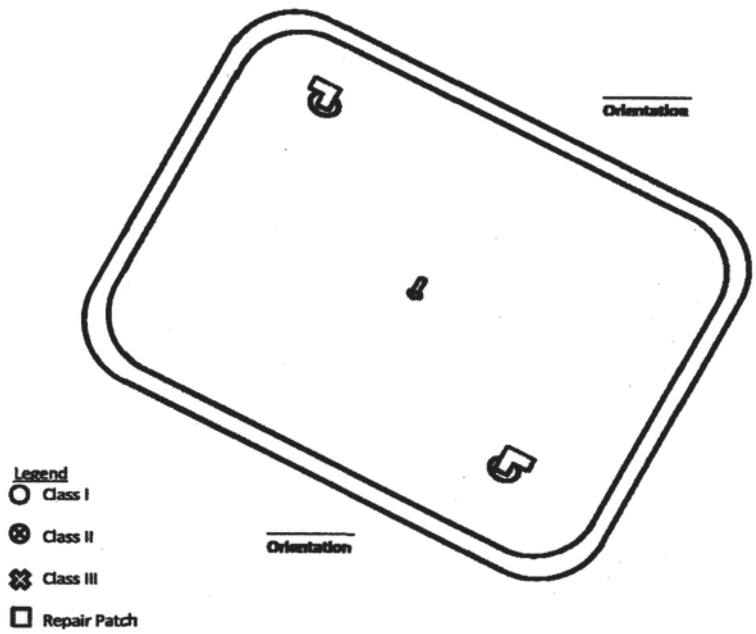
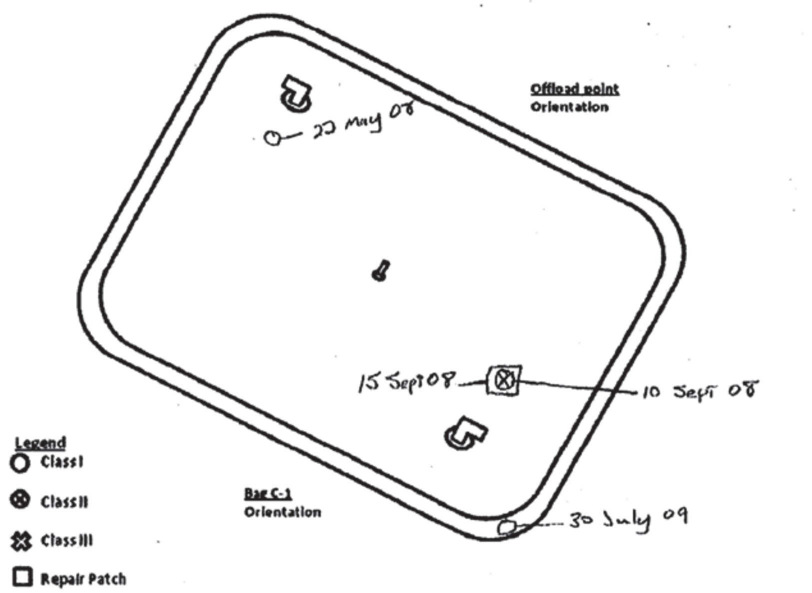


Figure H-2. Blank Bulk Storage Tank Record

Bulk Storage Tank Record

Location: ***Cedar II***
Manufacturer: **XYZ Tanks**
Manufacture Date: **Sep 07**
Lot &Serial No: **02/13**
Date In Service: **14 Jan 08**
Bag Number: B-1

Capacity: **50,000**
Product: **JP8**
NSN: **xxxx-xx-xxx-xxxx**
Contract #: **DAAE0701DT020**
Date Out of Service:



14 Jan 08 – Put bag in service
22 May 08- 3 inch wet spot developed two feet from inlet
10 September 08 – 4 inch class II leak developed six feet from outlet
15 September 08 -Repair patch applied to Class II leak.
30 July 09-class I leak developed on corner seam

Figure H-3. Completed Bulk Storage Tank Record

Glossary

SECTION I – ACRONYMS AND ABBREVIATIONS

Bbl	barrel
BCT	brigade combat team
BSB	brigade support battalion
CSSB	combat sustainment support battalion
DA	Department of the Army
DA Pam	Department of the Army pamphlet
DLA	Defense Logistics Agency
DoD	Department of Defense
DOS	days of supply
ESC	expeditionary sustainment command
FARE	forward area refueling equipment
FM	field manual
FSSP	Fuel System Supply Point
GPM	gallons per minute
IPDS	Inland Petroleum Distribution System
ISO	international standards organization
JP	jet propellants
JPO	joint petroleum office
MIL-STD	military standard
OPDS	Offshore Petroleum Discharge System
POL	petroleum, oils, and lubricants
PS	pump station
ROM	refuel on-the-move
SAPO	sub-area petroleum office
TSC	theater sustainment command
TM	technical manual
TPT	tactical petroleum terminal

SECTION II – TERMS

Offshore Petroleum Discharge System (OPDS)

Provides bulk transfer of petroleum directly from an offshore tanker to a beach termination unit located immediately inland from the high watermark. Bulk petroleum then is either transported inland or stored in the beach support area. Also called OPDS. (JP 4-03)

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References

REQUIRED PUBLICATIONS

These documents must be available to intended users of this publication.

ADRP 1-02, *Terms and Military Symbols*, 24 September 2013.

JP 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 08 November 2010.

RELATED PUBLICATIONS

These documents contain relevant supplemental information.

ARMY PUBLICATIONS

Most Army doctrinal publications are available online: <http://www.apd.army.mil/>.

AR 385-10, *The Army Safety Program*, 27 November 2013.

AR 710-1, *Centralized Inventory Management Of The Army Supply System,* 20 September 2007.

AR 710-2, *Supply Policy below the National Level*, 28 March 2008.

AR 710-3, *Inventory Management Asset And Transaction Reporting System,* 25 February 2008.

ATP 3-04.94, *Army Techniques Publication for Forward Arming and Refueling Points* 26 January 2012.

ATP 4-93, *Sustainment Brigade*, 9 August 2013.

DA Pam 710-2-1, *Using Unit Supply System (Manual Procedures)* 31 December 97.

DA Pam 710-2-2, *Supply Support Activity Supply System: Manual Procedures,* 30 September 1998.

FM 4-40 *Quartermaster Operations* 22 October 2013.

FM 27-10, *The Law of Land Warfare (INCL C1),* 18 July 1956.

TB 10-5430-253-13, *Technical Bulletin for Collapsible Fabric Fuel Tanks,* 8 December 2009.

TM 4-43.31, *Petroleum Laboratory Testing and Operations*, 30 May 2012.

JOINT PUBLICATIONS

Most joint and Department of Defense doctrinal publications are available online: http://www.dtic.mil/doctrine/new_pubs/jointpub.htm.

JP 4-0, *Joint Logistics,* 16 October 2013.

JP 4-01.6, *Joint Logistics Over-the-Shore,* 27 November 2012.

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DEPARTMENT OF DEFENSE PUBLICATIONS

Most Department of Defense publications are available online:http://www.dtic.mil/whs/directives/corres/pub1.html

DOD 4140.25-M, *DOD Management of Bulk Petroleum Products, Natural Gas and Coal, Vol I,* 28 June 2013.

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DOD Directive 5101.8, *DoD Executive Agent (DoD EA) for Bulk Petroleum,* 22 August 2004.

OTHER PUBLICATIONS

United States House of Representatives United States Code, Title X: http://uscode.house.gov/view.xhtml?path=/prelim@title10&edition=prelim.

MIL-STD-3004: *Quality Surveillance Handbook for Fuels, Lubricants, and Related Products*, 7 December 1012: http://www.dtic.mil/dtic/stresources/standards/.

RECOMMENDED READINGS

These readings contain relevant supplemental information.

ARMY PUBLICATIONS

Most Army doctrinal publications are available online: <http://www.apd.army.mil/>.

AR 200-1, *Environmental Protection and Enhancement*, 21 February 1997.

AR 385-30, *Safety Color Code Markings and Signs*, 15 September 1983.

TM 5-315, *Firefighting and Rescue Procedures in Theaters of Operations*, 20 April 1971.

PRESCRIBED FORMS

None.

REFERENCED FORMS

Unless otherwise indicated, DA forms are available on the Army Publishing Directorate (APD) website : <http://www.apd.army.mil/>.

DA Form 1296, *Stock Accounting Record.*

DA Form 2028, *Recommended Changes to Publications and Blank Forms.*

DA Form 2064, *Document Register for Supply Actions.*

DA Form 2765-1, *Request for Issue or Turn-In.*

DA Form 3643, *Daily Issues of Petroleum Products.*

DA Form 3644, *Monthly Abstract of Issues of Petroleum Products and Operating Supplies.*

DA Form 3853-1, *Innage Gage Sheet (Using Innage Tape and Bob).*

DA Form 3853-2, *Outage Gage Sheet (Using Innage Tape and Bob).*

DA Form 3853-3, *Outage Gage Sheet (Using Outage Tape and Bob).*

DA Form 4702-R, *Monthly Bulk Petroleum Accounting Summary.*

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ATP 4-43 (FM 10-67)
21 JULY 2014

By order of the Secretary of the Army:

RAYMOND T. ODIERNO
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